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VARIATION VERSUS HEREDITY.[1]

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IN proposing to discuss this subject I have no new examples either of variation or heredity to describe, nor any new evidence to bring forward, with which to confirm established beliefs regarding these two well-known and important factors of biology. But I would like to call attention to a point of view from which variation, which we are accustomed to regard as a kind of accidental and abnormal performance of organisms, looms up into a prominence second to no other phenomenon of life, and stands out as the fundamental and distinctive characteristic of living beings. From this point of view, natural selection in all its different forms, the direct and indirect effects of environment, and other processes which, according to the orthodox view, are believed to be agencies in promoting evolution, appear but subsidiary steps in the acquirement of heredity, and are concerned only in checking evolution and in bringing the organism into a state of subjection to the mechanical laws of the physical environment in which they live.

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It is taken for granted that readers are familiar with the orthodox, or common working hypothesis, of modern naturalists in regard to these matters; but, in order that we may be thinking alike, let me mention a few particulars to which special attention is directed.

(*A*) It is assumed to be the accepted belief that *organisms acquire their distinctive characters by the processes of natural growth and development.*

(*B*) That it is the accepted belief that those characters which in a particular organism are *like* the characters of its parents and ancestors are to be explained on the hypothesis of *heredity, i.e., that organisms naturally reproduce offspring like themselves.*

(*C*) That it is the accepted belief that the characters which are *unlike* those of the parents are explained on the hypothesis of *variation, i.e., that organisms differ slightly or vary naturally from their immediate ancestors.*

It will be noticed that the term *organisms* in the second statement refers to the *parents* in the case; in the third statement it refers to the *developing offspring.* I understand this to be the accepted view, *i.e.*, that it is assumed that the *causative factor* determining the hereditary reproduction of *like* characters is associated with the *parent;* and, on the other hand, that the causative factor of *diversity* is associated with the *individual varying* in response to diversity in the conditions under which it develops. Or, to put this whole idea definitely as a separate proposition,

(*D*) It is the orthodox hypothesis, regarding this question, that *an organism arising under conditions entirely similar to those of its immediate ancestors, would not vary from them, but would develop in perfect facsimile to them;* and, therefore, that *variation is incident to heterogeneity of environment.*

Is all this true? Or is not the very converse of it true? In opening the discussion of this question, let me refer to the opinions of the founders of the evolution theory on this point.

In the year 1861 Darwin wrote to Thomas Davidson: "My greatest trouble is, not being able to weigh the direct effects

of the long-continued action of changed conditions of life, without any selection, with the action of selection or mere accidental (so to speak) variability. I oscillate much on this head, but generally return to my belief that the direct action can have played an extremely small part in producing all the numberless and beautiful adaptations in every living creature" (*Life and Letters*, vol. ii, p. 369).

Fifteen years later, in 1876, in a letter to Moritz Wagner, is found the following statement: "In my opinion the greatest error which I have committed has been not allowing sufficient weight to the direct action of environment, *i.e.*, food, climate, etc., independently of natural selection" (*Life and Letters*, vol. iii, p. 159); and in the following year, 1877, he wrote Malchior Neumayr: "There can now be no doubt that species may become modified through the direct action of the environment" (vol. iii, p. 232). The above quotations show where Darwin located the cause of variation, both when writing the *Origin* and in the later period of his life.

Again, in a letter to Lyell, in 1860, we find this statement: "Talking of 'Natural Selection,' if I had to commence *de novo*, I would have used 'natural preservation'" (vol. ii, p. 346). And, in 1863, to Asa Gray, Darwin wrote: "I have sometimes almost wished that Lyell had pronounced against me. When I say 'me' I only mean *change of species by descent.* That seems to me the turning point. Personally, of course, I care much about Natural Selection; but that seems to me utterly unimportant compared to the question of Creation or Modification" (vol. ii, p. 371).

These letters show where Darwin placed the emphasis in his life work. *Modification of species by descent* is the great discovery, and natural selection and direct effects of environment he believed to be the chief factors in bringing about this modification; but they were really secondary to the great fact of simple evolution, or the modification of organisms in the course of descent.

His letters leave no doubt that what he meant by "Natural Selection" was "Natural Preservation"; the "Survival," as Spencer put it, of characters which have already arisen in

ancestors by variation, and, after being tried by experience, are found favorable to the organism possessing them, and are, therefore, reproduced in their offspring. Cope and Henslow and others have called attention to this unmistakable meaning of natural selection. And Wallace, in 1866, criticised Darwin's use of the term "Natural Selection" by saying, "Nature . . . does not so much select special varieties as exterminate the most unfavorable ones."

On the other hand, the recognition of the view that variation is the prime factor of evolution, was evidently in the minds of both Lyell and Asa Gray, and was one of the chief causes of their hesitation, at first, to accept in full Darwin's theory of evolution. But, as a theory to explain the *origin of species*, Darwin was right, for the fundamental characteristic of species is not variation, but the *persistent reproduction of like characters*, and natural selection and the direct and indirect effects of environment are the most potent agencies discovered in determining this persistent uniformity of reproduction. But producing uniformity is not evolution.

The founders of the modern theory of evolution, while they were united as to the modification of species by descent, and in assuming that natural selection and kindred agencies were conspicuous factors in the general process of evolution, were not uniform in the assignment of the part played by these factors. Nevertheless, in the expressions of philosophical opinion regarding these points, above quoted, we find they were aware that the immediate effect of natural selection, etc., was in the direction of making characters hereditary, in "preserving" them in the reproductive sequence of the race. With the preconception, and as I believe misconception, that heredity is the essential characteristic of living organisms, it was necessary to believe that the organism could not, *of itself*, evolve into something different; hence the natural conclusion that variation must be *induced* by external agencies, and natural selection, etc., are these agencies which stimulate and promote variation, and at the same time check and hinder it. Herein lies one of the great inconsistencies of the orthodox theory.

The point of view suggested in this paper corrects some of these inconsistencies.

One of the difficulties, which seems to be removed by the new point of view, is seen by noting the simple phenomenon which takes place in any concrete case of natural selection.

First: In any particular case of selection it is necessary *that some character*, which has appeared for the first time in the course of the growth of a particular organism, *should reappear in its offspring*. The character is said to be "transmitted"; it "survives"; it is "preserved" in the offspring. In order to be thus "preserved," it ceases to be a divergent and variable element in individual growth, and becomes a regular or hereditary character in the descendants.

So far as the character itself is concerned it was produced without any precedent before it was found to be either profitable or unprofitable, and in being preserved it is simply reproduced. So far as the principle of modification is concerned, the offspring which reproduces the variable character of its parent is *less* variable than its parent, and if natural selection causes the preservation of the character, to that extent it is effective in checking evolution.

Secondly: It is to be observed *that that which takes place in the varying individual differs in degree, not in kind, from the ordinary processes of growth, or individual development.* Variation is not some peculiar mode of action of an organism, but it is the same process by which the individual builds up its hereditary characters. In the ordinary growth, as the organism develops from the germ to the adult each step of progress in development is, for the cells undergoing the development, a process of variation from the behavior of the parent cells from which they arose. So long as the varying does not exceed the varying of previous organisms, the process is called individual development, and is purely hereditary. Whenever the varying results in producing structure not hitherto produced, it is evolution.

On the assumption that this hereditary process of reproduction is a necessary and fundamental function of organisms, it is necessary to assume that some new law comes into opera-

tion where development ends, and variation, the first step in evolution, begins. Whereas, in fact, it is difficult even to imagine how the closest possible scrutiny of the growing individual could detect the place where normal development ends and variation begins.

Variation, in any concrete case, is simply the development of the individual in some different way, or to a degree beyond the attainment of its parents; but it is, nevertheless, normal constructive development. The whole secret of individual development lies in the fact that in the reproduction of growing cells, the daughter cells are slightly different from the parent cells, greater uniformity occurring in each mass of the same tissue or organ, but absolute uniformity nowhere. The multiplication of similar cells in growth, and their gradual modification in the construction of dissimilar tissues and organs in development, are phenomena no less diverse than is the hereditary process of reproduction of individuals from the variational production of specific differences. Variation is exhibited whenever an organic body produces another body dissimilar to itself, whether that body be a cell or an individual. Heredity is exhibited in both cases in the phenomenon of reproducing that which has already appeared.

Thirdly: Let us take another view of the subject and note *the relation which variation and heredity bear to experience.* In any concrete case of a growing organism the construction of a character according to heredity implies the experience of having previously constructed such a character, on the part of the parent, which is conceived of as the controlling cause of the process. Variation, on the other hand, is, when it first occurs, spontaneous, in so far as that means previous to experience. So far as the individual, or the race to which it belongs, is concerned, the varying act is an original act; it does not depend upon specific experience. Heredity is, therefore, of the nature of habit or memory, and implies experience. Variation is, in its intrinsic nature, original and genetic.

Selection is one of the steps in the acquirement of heredity, and thus the "origin of species" by natural selection is the acquiring of a regular, or hereditary, method of development

for each series, or race of organisms, breeding and developing together under like conditions.

If varying brings about modifications which are beneficial, then that which promotes varying must be an advantage. But in order to originate a species, varying is checked, and it is only as natural selection checks, transmits, and preserves, *less variably*, the characters acquired by variation that the origin of species results.

Thus we discover that the application of this hereditary principle to organisms, as a fundamental characteristic of living processes, makes it necessary to assume that evolution does not work in harmony with it; but only by checking, antagonizing, and violating heredity is any progress attained.

On the other hand, on the view that variation is the ultimate principle of all vital phenomena and is operative (as it is known to be) prior to experience, evolution becomes the fullest expression of life, and heredity and relative uniformity of reproduction the most natural expressions of the economical adjustment of living organisms to the limitations of environment. Evolution, in other words, takes place, naturally, as fast as the construction of organization and adjustment to environment furnish the possible medium for its expression. On this hypothesis evolution becomes as natural and universal a process for organic bodies as gravitation is for physical bodies.

Fourthly: According to the current philosophy of evolution, struggle for existence is assumed to be a most important factor in determining the course of "selection," or "preservation," by which advance is made. This struggle for existence is assumed to operate in the way of overcoming competitors for the same sources of good; and fitness to survive is measured by the capacity to grow big.

This theory, that measure of success is amount of food an organism can assimilate, that growing fat is evidence of fitness to survive, is consistent with the belief that repetition of the characters of ancestors, or heredity, is the primary law of organisms; and it is this philosophy which would lessen competition as a means of promoting progress.

But we have only to observe the natural course of the history of every organism to see that the setting up of antagonisms is not only the fundamental but the necessary law of organisms.

The most strenuous struggle which occurs in the life of any organism is that which separates it from its closest ancestor, its most intimate helper, the source, at the time of the separation, of all its good. No struggle with competitors, afterwards, equals in proportionate expenditure of energy this one. In the higher animals the term *labor* has been applied to it, because all other labor is but a faint imitation of it.

This greatest and universal struggle is the means of breaking with ancestry and setting up independence. So far as the immediate parent is concerned, the amount of energy expended in preparing for, caring for, and building up this offspring, which must necessarily increase and not diminish the total difficulties of living, is in excess of any other kind of energy put forth by the organism. And as to the offspring itself, the separation from the parent is a departure from almost total dependence and inactivity into increasing struggle and labor.

Thus in this process, which we are apt to associate most intimately with the law of heredity, is seen in operation this principle of doing otherwise, of departure from the bonds of heredity, of variation from the immediately preceding course of action of the individual performing the acts. It seems to us, as we ascend a mountain, as if the rough things in the path were the real hindrances to progress, but the fact is that the great work of a climber is always spent in overcoming the gravitation which would keep him at the bottom, and adjustment to the rocks on the way of his path is an insignificant part of his task. So it is not so much the local impediments of environment as the inertia of heredity which has to be overcome in each step of progress of evolution.

Malthus's theory rests on the assumption that there are more applicants than there are goods; but whether this be true or not, it is certainly true that the greatest kind of human success we know of, and the most conspicuous examples of success, are those cases in which hitherto useless, because unused, sources of good are appropriated and their value realized, and thus the

way to new resources is opened. On the other hand, it is reliance upon ancestry, personal inactivity, failure to struggle, refusal to put forth the energy possessed, that constitute the curses of all organisms; and it is such evils that natural selection is constantly eliminating in the struggle for existence and the survival of the fittest. The first sign of headship and leadership and fitness to survive is a declaration of independence from the bonds of heredity. The place of greatest resistance, of hardest struggle, must be overcome before real progress can be made, and it is success there which is the first sign of fitness to survive and to perpetuate the race.

The very essence of virility, as of all evolution, consists in doing otherwise, — in varying from the past, in transgressing tradition, not violating but surpassing the laws of heredity. And the measure of success in such struggle is not accumulation of resources, but increase of productiveness. The most successful is the one which gets most result out of the resources at hand, and such success survives. But this is the law of variation, not heredity.

Fifthly: In order further to test the correctness of this hypothesis, it is important to examine the real *meaning of this phenomenon of variability.* What is the real fact to which attention is called by saying a species or an organism varies? Is there only a rearrangement of unchanging atoms? Is there something new originated? And what is the result of varying?

Darwin's theory of pangenesis, and the various other attempts, up to the most elaborate of all, Weismann's theory of germ plasm, which conceive of some sort of physical basis for the differences which arise in organic processes, are an indication of a belief that evolution does not originate anything new, that it merely seems to do so; and that organisms, like inorganic bodies, are substantially immutable. This mechanical theory provides for two categories, — things and acts, — into which objective phenomena may be distributed: things whose chief distinction is that they are posited and extended in space, and acts posited and extended in time. We cannot observe anything as absolutely inactive, nor can we observe any real act separated from some form of thing. But in imagination

the physicist abstracts the thing-in-itself, or the substance of things, as matter, which in its ultimate nature, as atoms, is unchangeable — immutable. In like manner, he abstracts from experience the substantial basis of observed actions and calls it energy. Thus in the working hypothesis of physics, the substantial basis of particular acts is energy, exactly as the substantial basis of particular things is matter. But the physicist finds no place in this hypothesis for any variation in the ultimate kind, amount, or constitution of these two substantial bases of experience. All differences in phenomena are, to this theory, different arrangements of immutable units.

The application of this hypothesis, of the immutability of the essence of things, to the phenomena of living organisms requires us to assume that there are some kinds of ultimate immutable units back of organisms, which necessarily behave uniformly, except as they may be diverted by the action of some force from outside. Thus, I suppose, has arisen the almost universal belief that the uniform behavior of organic bodies, which we define by the term *heredity*, is a necessary and fundamental characteristic of organic units, just as inertia is a characteristic of inorganic bodies. The final outcome of this view is the assumption of the existence of separate and immutable units for every divergent phenomenon of organisms. Darwin evidently adopted some such view, and I do not see that the followers of Darwin have escaped this fundamental conception in elaborating the general evolution hypothesis. But the first step toward correcting it was taken when the idea of immutability was dissociated from the organic species.

Cuvier was the last of the great naturalists to maintain the immutability of species. It was the recognition of the intrinsic mutability of the organic species that made a rational theory of evolution possible, and it is my sincere conviction that a consistent theory of evolution cannot be built up which stops here. I cannot discover that there is any halting place. In order to explain the wonderful phenomena of organisms, the principle of mutability must be extended to the ultimate units of which every living body is composed. Not only the species, but the individual, the cell, the units which constitute the living

form of protoplasmic matter, must be conceived of as in a normal state of mutability.

That which makes an organic body to be vital, and distinguishes it from matter in an inorganic state, is this constant and incessant varying.

Recognizing this as the fundamental characteristic of living matter, it is very easy to conceive how varying will proceed constantly and in all directions, like a gas expanding, except when checked and guided by the impact and restraints of external conditions.

I have now stated briefly the meaning of the proposition that *variation, and not heredity, is the fundamental characteristic of the phenomena of organisms,* and a few of the arguments which recommend this view to consideration and acceptance as a working hypothesis for future investigation.

These arguments may be stated briefly as follows :

First : In any concrete case of natural selection, or similar processes, the actual result of selection is the retarding and checking of variation ; and the offspring necessarily evolves more slowly than its parent, in direct proportion to the efficacy of the natural selection.

Secondly : That the organic processes by which variation takes place in an organism differ from the ordinary process of development in individual growth only by passing beyond the limit reached by the ancestor; and hence variation is but a phase of the fundamental genetic process peculiar to living organisms.

Thirdly : That every act of variation is anterior to experience, and thus is necessarily original and genetic, whereas every hereditary act is necessarily secondary to, and the result of, experience, and that the law of heredity must, therefore, be acquired in the process of evolution, and is not fundamental.

Fourthly : That, as to struggle for existence, the most strenuous effort that is made (both by the parent and by the offspring) in the course of organic processes is that which produces antagonism of interests. On the part of the parent, it parts with that which has cost it the greatest expenditure of energy ; and on the part of the offspring, the result is the loss, in part or wholly, of the only source of its living up to the moment of the struggle.

Fifthly: That the orthodox view of the case is inconsistent, in so far as it recognizes mutability as applicable only to organic species, and clings to the idea of immutability of the more fundamental units of biology, *viz.*, the individual, the cell, and the protoplasmic states of matter.

These considerations bring us to a point of view in which heredity and variation hold a different relation to evolution than in the ordinary working hypothesis of biology.

If this point of view presents the facts in their true relations, we must seek for the immediate determining causes of variation, not in natural selection, nor in any of the environmental conditions, either direct or indirect, by which hereditary repetition is established, but in the phenomena of individual growth and development, and in the more fundamental processes of cell growth and metabolism.

NEW HAVEN, CONN.,
August 15, 1898.

A BASIS FOR A THEORY OF COLOR VISION.[1]

WILLIAM PATTEN, PH.D.

PART I.

THE physiologists and the psychologists have carefully studied and compared the sensations caused by ether waves of various lengths, and have attempted to explain how these manifold sensations of light and color are produced. But a satisfactory theory of color vision can never be worked out in this way, any more than a comparative study of the sensations produced by sticking different kinds of pins into the body will enable us to predict the internal sequence of events aroused by such treatment. To do that, the anatomist must first tell us what the internal mechanism is like. But he has told us very little about the retina. In fact, all that we know about its structure, either in man or in the lower animals, might be lost to science without seriously affecting the generally accepted theories of color vision. Any facts, therefore, that may possibly explain how different kinds of ether waves produce a differential response in nervous structures will be very welcome. The problem of color vision, like that of hearing, is primarily a mechanical one. We may be sure that since the stimulant that produces in us the sensation of light and color is a series of waves of definite length and frequency, the things responding to these movements must have a definite structure and position, whether they are molecules, or nervous plates, or bars, or fibrils; and their structure and position must determine the kind of waves to which they respond.

The conditions are in some respects similar to those in the ear, but they are different in so far as the cochlea possesses a

[1] This paper was read before the American Physiological Society at Ithaca in December, 1897. It appeared by title a year earlier on the programme of the Morphological Society, but, owing to lack of time, a five-minute abstract only was read.

series of fibres, or hairs, over which sweeps the whole gamut of sound waves, each wave length probably affecting one element only as it passes along the keyboard. In the eye, on the contrary, every point in the most sensitive part — that is, every cone — appears to possess within itself a mechanism similar to that in the whole cochlea, for it responds at the same time to almost any wave length from red to violet, or to many combinations of them.

It is, therefore, to the rods and cones that we must look for the solution of our problem. They are very small transparent bodies and apparently structureless. It is true that in Sir Isaac Newton's time there were supposed to be three sets of fibres in the retina, the stimulation of one set initiating mainly the sensation of red, another that of green, and the third that of blue. By combining these three sensations in various ways, it was thought that all the remaining color sensations could be produced, just as we can produce all the other spectral colors by mixing red, green, and blue light. Subsequently, various imaginary chemical compounds were substituted for the fibrils. But no evidence has been produced to show that these things exist. The physiologist "makes believe" these substances are present in the retina, but he is very careful not to say just how they should be distributed in order to produce the effects that actually are produced; or why one substance responds to one wave length more than to another; or how the single or combined responses are transmitted without confusion and loss of individuality to the cerebral centres. I believe that a reasonable answer can be given to these questions if we can only clear our minds of old traditions and look at the problem from a new standpoint.

A comparative study of the visual elements gives us this new point of departure, and we venture to offer a theory of color vision based on the fact that the rods and cones, or the parts corresponding to them in the lower animals, are not homogeneous, but fibrillated, and that in a number of invertebrates the fibrils are arranged according to their length in accurately graded series, and in such a position that they always stand at right angles to the rays of light that fall on

them. The ether waves thus vibrate across a series of fibrils of different lengths.

We assume that the length and position of a fibril determine the amount of its response to an ether wave of a given length, and as each visual cone contains a complete series of these fibrils, we may understand how each cone responds to the entire series of visible ether waves or to various combinations of them; and since the rods and cones vary in shape and in size in the retinæ of different animals, or even in different parts of the same retina, there should be a corresponding variation in the length and in the number of fibrils they contain, and consequently a corresponding variation in the powers of color vision.

I shall first describe the structure and arrangement of the retinal cells in some invertebrates, omitting, of course, many details that cannot be introduced into a paper of this character. Then, assuming that the human retinal cells have a similar structure, I shall try to show how we may explain many phenomena of color vision on that basis.

More than twelve years ago I described a series of what seemed to be nerve fibrils arranged with great regularity in the rods and retinal cells of mollusca and arthropods (*Mitth. aus Neapel*, 1886). Although from time to time I have confirmed and considerably extended my original observations, no other investigator appears to have made a serious attempt to do so. But indirectly the observations have received ample confirmation, since my description of the nerve endings in the retinal cells are in complete harmony with the best recent results obtained from the study of other organs by the methylen-blue and the gold-chloride methods.

We have not found these fibrils in the rods and cones of vertebrates, but there is no good reason to doubt their existence there, since, as I shall show elsewhere, the retinal cells in both vertebrates and invertebrates agree in many important details.

Whether these fibrils in the rods are nerve fibrils in the usually accepted meaning of the term need not detain us here. It will be sufficient for our purpose if we can show that these

sensory cells contain fibrils that may act as conductors or as resonators to certain kinds of movements.

The following is a very brief statement of the most important conclusions we have reached concerning the structure and arrangement of retinal cells.

(1) *Structure of a Retinal Cell.* — A typical retinal cell or retinophora, such as those found in molluscs and arthropods, although it has the outward appearance of an ordinary sensory cell, is in reality a double, or twin, cell. It consists of two nearly equal parts, readily distinguished by differences in optical properties; each part contains a nucleus and supports half of the rod (Fig. 1[1]). A large nerve fibre is attached to the base of the cell and there breaks up into a dense mass of fibrils that penetrate and surround the cell and the rod. Although there is no sharp demarcation between them, we are able to distinguish three sets of these fibrils. The first set consists of comparatively coarse fibrils running lengthwise of each retinophora between its two parts; they are often closely united to form a distinct axial bundle extending into the rod and sometimes beyond its outer end. The second set ramifies over the surface of the cells and the rods. Some of them appear to be independent intercellular nerve fibres not united with the large bundle attached to the base of the cell. The third set is found mainly in the rods, where they form what I have called a *retinidium*, which consists of a series of extremely delicate transverse fibrils that appear to unite the coarser axial and the superficial rod fibres with one another. These cross fibrils give the rods either a finely dotted or a striated appearance, according to the direction from which one looks at the fibrils.

Such a retinal cell, therefore, appears to contain a mass of fibrils which extend through the center of the cell into the rods, where they bend at right angles and become continuous with those on the peripheral layers. At the base of the cell all the fibrils are gathered together to form an axis cylinder, and after extending some distance, they separate and end freely.

(2) *Position of the Visual Rods.* — The rods may be upright, inverted, or, very rarely, horizontal, as in the ocelli of some

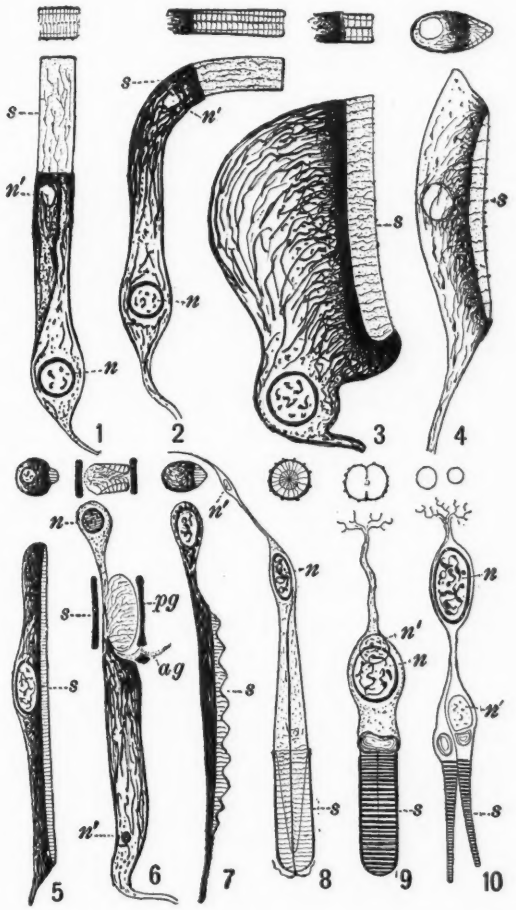

FIG. 1. — Various forms of retinophoræ, isolated by maceration and showing position and shape of retinal rods. Cross-sections of the rods are shown over each figure, the place where the section is taken being indicated by the letter *S*. 1, upright terminal rod from ocellus V of Acilius (see Fig. 2) ; 2, horizontal terminal rod from sides of ocellus II of Acilius (*cf.* Fig. 3); 3, a giant retinal cell with short horizontal rod from ocellus II; 4, retinal cell with lateral rod from compound eye of Limulus; 5, retinula cell from compound eye of Tabanus; 6, retinal cell from the ocellus of Lycosa; 7, retinula cell with serrated rod from the compound eye of Pinæus; 8, inverted retinal cell from the eye of Pecten; 9, rod cell from retina of an Amphibian (species of Diemyctylus), showing two nuclei, n' and n, and indications of division of rod into two parts with either a canal or fibre running through a part of the rod; 10, cone cell from same animal, showing double nature of the cell as well as of the cone. The body corresponding to the second nucleus lies at n'.

insects; or they may be terminal or lateral, as in either the simple or the compound eyes of arthropods. But in all cases, except the small horizontal rods of *Acilius*, the long axes of the rods are parallel to the rays of light falling on them, as shown in Fig. 1, where the light in each instance is supposed to come directly from above.

(3) *The Shape of the Rods in Cross-Section and the Arrangement of the Retinidial Fibrils.*— The shape of the rods in cross-section is a matter of great importance, because it usually indicates how the retinidial fibrils are arranged. The cross fibrils lie in superimposed planes, generally placed in one of the following positions: (*a*) When the rods are cylindrical, the cross fibrils radiate from the centre of each rod, like the bristles of a test-tube cleaner (Fig. 8, *A*, Pecten). (*b*) When the rods are quadrilateral in section, as in Acilius and Lycosa, all the cross fibrils in the same transverse plane are nearly parallel (Fig. 8, *B*, *C*, *D*). (*c*) When the rods are bound together in groups of from three to eight, as in the compound eyes of many arthropods (Tabanus, *E*, Bdellostoma, *F*, Dytiscus, *G*, Fig. 8), the angular relations of the cross fibrils will vary with the number of cells in the retinula. (*d*) In some crustacea (Penæus) the rods are serrated and dovetailed into one another in such a way that certain cross fibrils in a given transverse plane are parallel to one another, but at right angles to those in the planes above and below them (Figs. 1[7] and Fig. 8, *H*).

But whatever may be the position or shape of the rods, their retinidial fibrils always stand at right angles to the rays of light that fall on them. This is shown in Fig. 1, where all the retinal cells are seen in their natural positions. Over each figure is a cross-section of the rods, showing the direction of the retinidial fibrils. These figures, however, give only a very rough idea of the number and delicacy of the fibrils. The modifications of the shape and of the position of the rods that may occur without changing this arrangement of the fibrils are very curious and interesting, but they cannot be detailed here beyond what is given in the figures.

(4) *Position of the Retinidial Fibrils in Different Ocelli of the Same Animal.* — Where there are several pairs of ocelli in the

same animal, as in Acilius and in Lycosa (Figs. 4 and 5), the retinidial fibrils in one pair are nearly at right angles to those in two other pairs, so that the animal may be said to have its

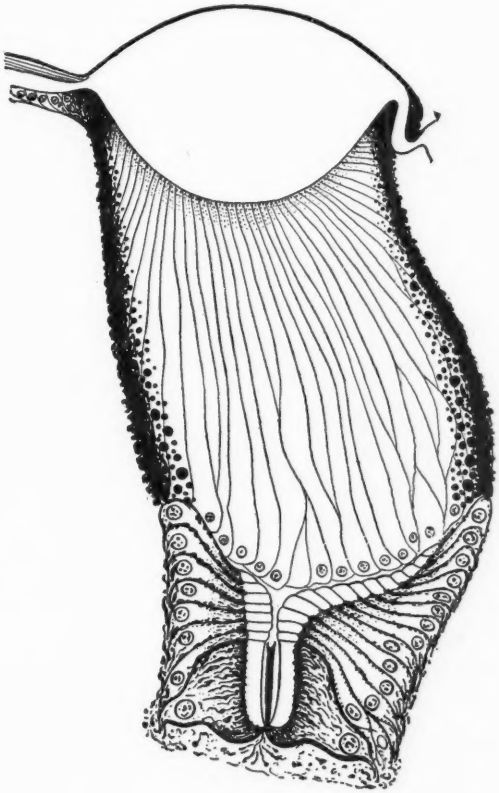

FIG. 2. — Vertical section through ocellus III of Acilius.

retinidial fibrils arranged in the three planes of space, like the hairs in the semicircular canals of the vertebrate ear. But it is a curious fact that in Acilius the pair of ocelli marked No. VI — and in Lycosa the anterior median pair — do not have their retinidial fibrils arranged in parallel lines. The arrangement of the ocelli on the right side of the head of Acilius, as seen from

above, is shown in Fig. 4. One looks down into the boat-shaped retinas of ocelli I and III, the shape of which in cross-sections is well shown in Fig. 2. In these ocelli the flattened ends of the rods (shown on a larger scale in Fig. $1-^{1-3}$) are seen as short, nearly parallel lines, the retinidial fibrils, not represented in the figures, running at right angles to them. The median band of pigment and the double row of giant rods are indicated by heavy lines. The retina of ocellus V is seen end-

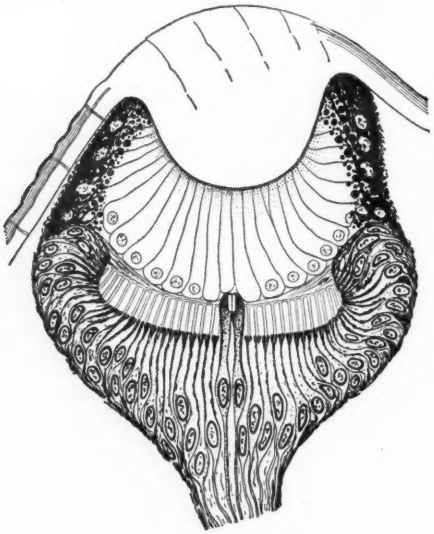

FIG. 3. — Section through ocellus V of Acilius.

wise, as though retina III were rotated 90° on its long axis and then stood on end, bringing the row of giant cells in a vertical position; see also Fig. 3. We therefore view the rods flatwise and lengthwise. Retinas II and IV are like those of eyes I and III, but smaller. They are placed so that the space between the two rows of giant cells lies in the plane of the paper, consequently we are looking at the giant rods lengthwise and edgewise.

In Lycosa the retinas I, II, and III show a similar orientation to the three planes of space. These three retinas are in every

way similar to each other except as to size. A single retinal cell is shown in side view in Fig. 1–6 and a section of the retina in Fig. 6; this section is cut through ocellus II (Fig. 5) vertical to the plane of the paper and at right angles to the zigzag lines of pigment. On the right side of Fig. 5 these cells are shown, on a somewhat larger scale, in the three positions they occupy in the corresponding ocelli. An enlarged section nearly parallel with the surface of ocellus II (Fig. 5) is shown in Fig. 7. On the right of this figure the section plane is deeper, show-

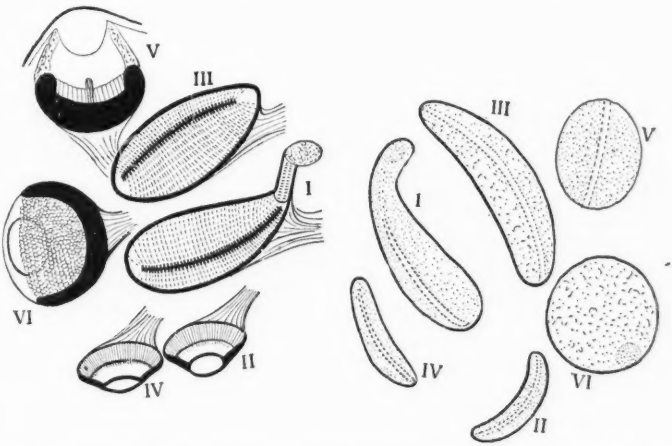

FIG. 4. — Diagram to show the arrangement of the rods in the ocelli of Acilius, and the way in which the fibrils of the optic ganglia resemble in arrangement those in the corresponding retinas.

ing the argentea and the ends of the rod cells. A comparison of these figures shows that the rods are arranged in zigzag rows, fenced off on either side by a band of pigment, and with a concave reflecting membrane beneath each row. The rods contain parallel fibrils (Fig. 7), and they are conical both in cross and in longitudinal section (Fig. 5, I^a and II^a). The rods in the centre of the retina are very small, gradually increasing in size towards the periphery. We have here, therefore, a most beautiful arrangement, one obviously adapted to bring the rods, and the rods only, into definite relations to the rays of light.

While it is clearly an advantage to have stationary eyes directed towards the three planes of space, it is not so clear why the fibrils should be oriented to these planes. As chiten is said to be doubly refractive, it seemed probable that there was some relation between the presence in arthropod ocelli of chitenous polarizing lenses and parallel retinidial fibrils. But in the cases that I examined there was apparently no polarization in the principal axis of the lens, although I am not satisfied that renewed experiments may not give different results. In making the experiments I was strongly inclined to believe that in these ocelli the light was polarized in such a way that it would vibrate at right angles to the retinidial fibrils.

(5) *The Retinidial Fibrils are Arranged in accurately Graded Series according to their Length.* — The visual rods, in all the cases studied, could be resolved into a series of simple or compound wedges, hence the retinidial fibrils ought to vary in length according to their position in these wedges. The difference in length between the adjacent fibrils, although excessively small, should vary with the angle, and the number of fibrils in the series should vary with the altitude of the wedges.

PART II.

There is no reason to doubt that the structure of the visual apparatus in the higher vertebrates is essentially like that in the invertebrates, for we have succeeded in demonstrating that the retinophoræ in fishes and amphibia are twin cells like those of molluscs and arthropods (Fig. $1–^{9}$). We can also demonstrate that the twin cone cells of amphibia are nothing more than extreme types of the same kind of cells (Fig. $1–^{10}$). Furthermore, the presence of retinidial fibrils, like those of invertebrates, is clearly indicated by the well-known transverse cleavage of these rods and cones, but the fibrils themselves are probably too minute and too numerous to be clearly seen under any conditions we are as yet able to command. They are presumably arranged in distinct layers, alternating with the clear matrix of the rods and cones. Without further discussion of this point here, let us assume that the retinophoræ of verte-

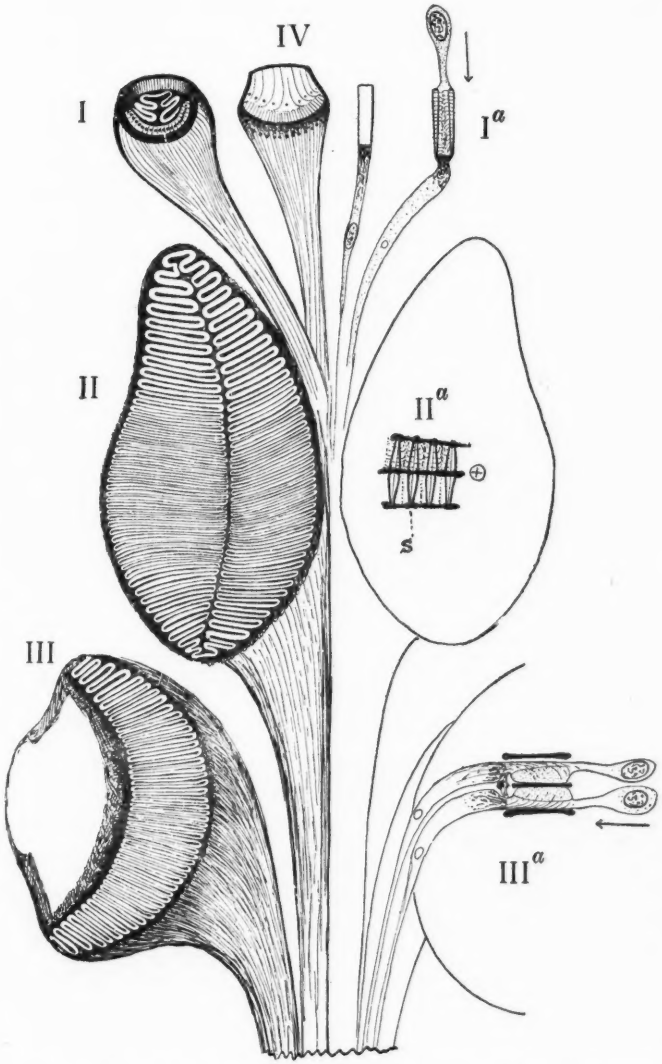

FIG. 5. — Diagram to show the arrangement of the retinal cells in the ocelli of a spider, Lycosa. The retinas, as seen from above, are shown on the left, and the position of the corresponding retinal cells, on a larger scale, on the right.

brates are like those of invertebrates, and that the retinal cones in man have a structure something like that shown in the accompanying diagrams (Fig. 9). In Fig. 9, a cone is seen in longitudinal section with the radiating fibrils on the right of the axial fibre ; on the left are projected three color curves with maxima nearly opposite *R*, *Gr*, and *V*.

Let us assume that the longest visible ether waves produce the greatest stimulation when vibrating at right angles to the longest retinidial fibrils, and the shortest visible waves produce the greatest stimulation when vibrating at right angles to the shortest fibrils. All the fibrils should be stimulated to some extent by all visible ether waves, and there should be a gradual diminution from the maximum to the minimum stimulation of any fibril according as it becomes either too short or too long to give the maximum response to an ether wave of a certain length ; or provided the fibril has the optimum length, according as it diverges from a position at right angles to the plane of vibration and to the line of propagation of the wave, toward one parallel with the plane of vibration and at right angles to the line of propagation. Now let us see what will happen if we use the simplest possible stimulant, namely, a ray of light consisting of one wave length only and vibrating in one plane, that is, a polarized ray of monochromatic light. Then let us imagine, merely for economy of words, that the fibrils most stimulated by certain ether waves become luminous with the corresponding colors. Then (1) if a ray of polarized red light passes lengthwise of the cone, it should stimulate most the longest fibrils and those most nearly at right angles to its plane of vibration and to the long axis of the cone. This should produce a band of red fibrils, brightest opposite *R*, as indicated by the thickness of the lines, and fading out above and below that level, where the fibrils become either too short or too long to make the maximum response. In a cross-section of the cone opposite *R* (Fig. 9, *B*), the fibrils at right angles to the plane of vibration, say at *a*, *b*, should be the brightest, fading out on either side towards the fibrils at *c*, *d*, which, being parallel with the plane of vibration, should be stimulated but very little, if at all.

(2) If the ray were unpolarized, there would be the same maximum stimulation at R as before, with a diminution of the stimulation on either side, above and below, but all the fibrils in the same transverse plane would be stimulated alike, because all the fibrils would be at right angles to at least one plane of vibration. We may, therefore, represent graphically the effects produced by a ray of polarized or unpolarized red light by the

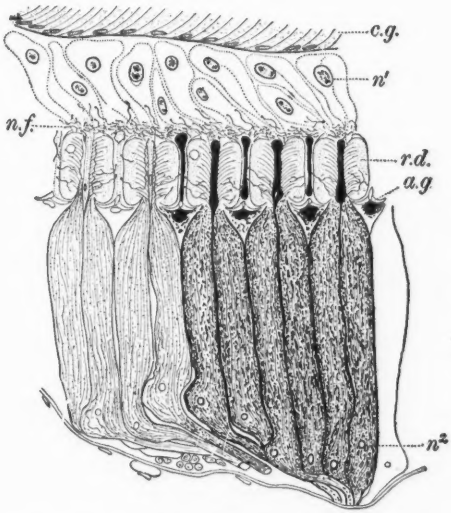

FIG. 6. — Vertical section of ocellus II of *Lycosa*. The section is cut at right angles to the rows of rods seen in Fig. 5.

curve r (Fig. 9, A). It should attain its maximum height a little way from the base of the cone and gradually fall to zero towards the apex, where the fibrils are too short to be affected by long ether waves. The curve will fall away more rapidly at the base of the cone because the long fibrils are supposed to terminate abruptly there.

(3) Similar results should be produced opposite V on stimulation with violet light, and of course similar results would again be produced at any intermediate point between R and V by using monochromatic light of a corresponding intermediate wave length. The stimulation curve for violet light would have

its maximum at *V* and would gradually fall away towards the base to zero. In the opposite direction the curve will be sharper, because the short fibrils terminate abruptly at the truncated apex of the cone. The curve for yellow-green light, on the other hand, with its apex opposite *Gr*, will be symmetrical because there is an equally long series of fibrils on either side of the maximum, which can respond to some extent to green light ; those on one side being too short, and those on the other too long.

(4) If a beam of polarized white light be passed through the cone, the stimulated fibrils would, if luminous, appear as two opposite spectra, wedge-shaped in cross-section, extending the whole length of the cone. All the fibrils in any one transverse plane should have the same color, but the intensity of the color should gradually diminish in those fibrils that become more and more nearly parallel with the plane of vibration. The fibrils at successive levels in the cones would of course be of different colors, and these colors would be arranged lengthwise of the

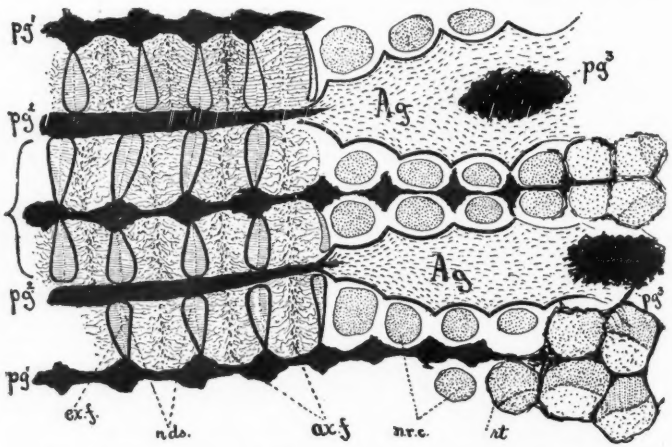

FIG. 7. — Section nearly parallel with the surface of the retina of ocellus II of Lycosa.

cones in the same order as those in the spectrum. The gradation of colors in such a spectrum would be more or less abrupt, according to the angle of the cone and its altitude ; that is, it

would be determined by the number of fibrils in the lineal series and upon the difference in length between adjacent fibrils. The precise colors exhibited at any part of the cone would

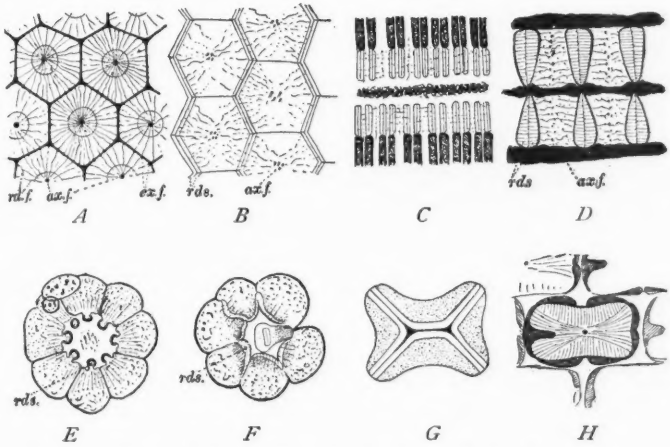

FIG. 8. — Sections through the rods of various invertebrates. *A*, Pecten; *B* and *C*, Acilius; *D*, Lycosa; *E*, Tabanus; *F*, Bdellostoma; *G*, Dytiscus; *H*, Penæus.

depend on the length of the fibrils at that point, while the range of colors exhibited would depend on the difference in length between the longest and the shortest fibrils. But the fibrils at different levels would not be equally luminous ; first, since the physical and chemical properties of protoplasm must set a limit to the length of ether waves to which such fibrils can respond, it is probable that the fibres of medium length would respond better to their appropriate stimuli than the extremely long or short ones. And again, as already pointed out, since the series of fibrils terminate abruptly at the base and at the apex of the cones, unsymmetrical luminosity curves for the red and violet light should be produced with maxima, respectively, at *R* and *V*, while the luminosity curve of the intermediate yellow-green fibrils should be symmetrical. But since there is a double summation of stimulation in the middle region of the cones, — due to the partial stimulation of the fibrils that are shorter and those that are longer than the mean, — the

medium length fibrils should appear more luminous than those on either side of them. For this reason the middle part of the spectrum appears the most luminous, shading off on either side towards the absolute blackness of the ultra-red and ultra-violet.

(5) If we passed through the cone a ray of unpolarized white light, it should appear brighter than a polarized one, because it would stimulate all the fibrils in the same transverse plane. But in other respects the fibrils at different levels would present the same color effects as with polarized light.

(6) The sensation of whiteness is apparently the result of stimulating all the fibrils in one or more sectors of the cone to a nearly equal degree. Obviously, this may be done by passing through the cone all wave lengths from red to violet, or by selecting any two or more wave lengths at such a distance apart in the spectrum that through summation effects all the fibrils will be stimulated to a nearly equal degree. But if, for example, red and green light is selected, the place of maximum stimulation, owing to the summation of the two effects, will be at a point midway between the red and green fibrils, that is, at the level of the yellow fibres ; hence the sensation of yellow will predominate, but it will be less saturated than the pure spectral yellow.

(7) The colors visible to a given animal should depend primarily on the various diameters of the visual elements, and the range of colors visible should depend on the difference between the maximum and minimum diameters. Hence any variation in the form or dimensions of the visual elements should be accompanied by corresponding variations in color vision. For example, increasing the length of the cones should increase the total number of fibrils of all lengths in them, and hence should be accompanied by increased powers of discrimination in all parts of the visible spectrum. We may therefore attribute the increased sensitiveness of the retina at the fovea to the greater length of the cones there, for each cone is thus provided with a greater number of fibrils to respond to any wave length within the range of vision.

Again, increasing the diameter of the base of the cones

should be accompanied by an increased range of vision at the red end of the spectrum. If the base of the cone were absent, red blindness should follow; but if the base of the cone should become cylindrical, with a diameter approaching that at *V* or *G*, then red blindness would follow, but accompanied by increased sensitiveness to the various shades of yellowish-green, because shortening the red fibrils would add so many more to the yellowish-green set.

We may also account for the gradual diminution in sensitiveness to red light toward the periphery of the retina by the fact that the cones, the bases of which alone contain the long red fibrils, diminish in number in that direction. On the other hand, on the outermost margin of the retina, all sense of color is lost and the sensation of black

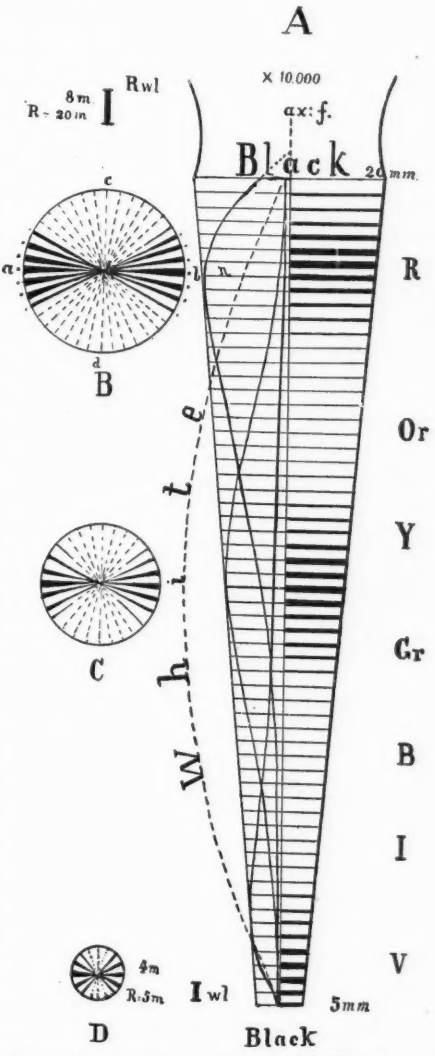

FIG. 9. — Diagram to illustrate the supposed fibrillar structure of the human cones and the way in which various light waves affect the fibrils.

and white alone remains. But this is not surprising, because towards the periphery the cones gradually disappear and the rods become the predominant elements; but since they are cylindrical bodies of uniform diameter, they must contain fibrils of one length only, — somewhat shorter than the longest cone fibrils, — consequently they cannot give rise to varied color sensations. Moreover, the periphery of the retina, judging from the manner in which the periphery grows in the invertebrates, is the youngest and least differentiated part, consequently we should not expect to find fibrils in that region which had attained just the length, position, and connections necessary in color vision.

These examples, I believe, are sufficient to show that it is a comparatively simple matter to account, from our point of view, for the more characteristic phenomena of color blindness.

(8) *The Development of Color Vision* may be explained in a similar manner. If color vision depends on the nice gradations in length or position or connection of these retinidial fibrils, the absence of these conditions should produce color blindness, but not necessarily inability to distinguish differences of light and shade. Many eyeless invertebrates react to very delicate gradations of light intensity, probably by means of the irregular networks of nerve fibrils between the epithelial cells of the naked skin. As these fibrils become phylogenetically more regularly arranged within the specialized sensory cells which serve to support them, the power to discriminate different colors should become more and more highly developed. But these conditions do not call for any particular sequence in the evolution of color sensations, for there is no reason to suppose that one set of fibrils of a given length and position would appear before another, except perhaps that a set of medium length would probably appear before the extremely short or extremely long ones, hence the sensation of yellowish-green should be the first one to emerge from that of whiteness, and subsequently it should be the most dominant and acute color sensation.

But if our views are correct, the only way in which the evolution of color vision can be worked out is by extensive

measurements, much more accurate and detailed than any heretofore made, of the visual elements in all classes of animals (also in different parts of the human retina), accompanied by an experimental study of their reactions toward different colors.

(9) *Length of the Retinidial Fibrils.* — The variation in length of organic fibrils capable of responding to ether waves is rather narrow, since there is but slight variation throughout the animal kingdom in the radius of visual rods. The length of the cross retinidial fibrils, using the radius of the rods as a guide, appears to vary roughly from less than 1 to about 4μ in length (Bdellostoma). The length of the rods may vary considerably more than this, but, as already stated, this may be taken to indicate the varying number of superimposed fibrils they contain.

The length of the retinidial fibrils in any individual must be determined primarily by the physical and chemical properties of the available protoplasm without reference to any possible advantage to be derived from a response to ether waves of a particular length. For surely there is no obvious reason why animals should not utilize for visual purposes ether waves several octaves higher or lower than they do now, if only the necessary end apparatus could be produced. But since the form of the vertebral column, or of a mountain range, is the resultant of its own composition and of the forces acting on it, and since the forms actually produced are the only ones possible under those conditions, so the form and position of the retinidial fibrils must be fixed by the inherent properties of the fibrils themselves, modified by the ether waves acting on them. We may infer, therefore, that, on the whole, animals respond to all those ether waves which are capable of modeling their available protoplasm into resonant parts.

It might be fairly demanded that since the extreme red waves visible to us are about twice as long as the extreme violet ones, the longest retinidial fibrils should be approximately twice as long as the shortest fibrils. But, judging from the very unsatisfactory data at hand, they appear to be about four times as long. For example, the longest retinidial fibrils, situated at the base of the human cones, should be about .0025 mm.

long, or about three times as long as the dark red waves. The fibrils at the apex of the cones are about one-quarter as long, or .0006 mm., or about one and one-half times longer than the violet waves. These figures, of course, are comparatively rough estimates, for exact and trustworthy measurements of fresh cones are wanting ; but they will serve to show the relations existing between the probable length of the fibrils and the ether waves to which they respond.

Since there is only one kind of an impulse sent over nerve fibrils, the discrimination of different stimuli must be determined mainly by the points of departure and arrival of impulses, that is, by the particular order and combination of fibrils stimulated ; and this in turn is determined by the position and length of the peripheral end fibrils. Such an end apparatus as we have described as existing in the human retina is apparently adequate to receive and differentiate any conceivable combination of light waves that may fall within the area of one or more cones. But in order to utilize the full capacity of such an end apparatus, each and every receiving fibril should be connected by a separate wire with the central station in the optic ganglion (or *tectum opticum* of the mid-brain in lower vertebrates or *corpora quadrigemmina* of higher vertebrates), and that in turn should be united in a similar manner with the cerebral hemispheres. But the well-known limitations of the human visual apparatus clearly demonstrate that its connections cannot be as complete as this.

The same conclusions may also be drawn from the known structure of the retina itself. For while there are supposed to be about three and a half millions of cones and about one hundred and thirty million rods in the retina, there are only about half a million fibres in the optic nerve. Now, as every one knows, the fibres of the rod and cone cells extend only to the inner molecular layer, where they end freely in terminal brushes (Fig. 10) ; there the nervous impulses transmitted by these cells are probably picked up by a second set, which in turn end at the outer molecular layer ; and here the impulses are apparently again transferred to a third set, which send their fibres along the optic nerve to the optic centres. There are

thus three principal sets of elements, an outer, middle, and inner, through which the nervous impulses must pass before reaching the optic ganglion. The number of elements in each set, as is obvious from even a superficial examination of the retina, decreases rapidly from the outer set towards the inner, while the territory covered by their terminal brushes increases from within outwards. In other words, one element in the

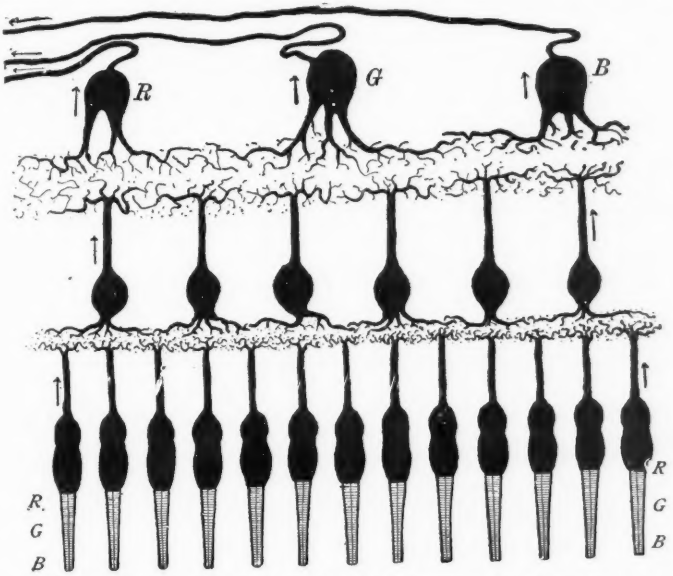

FIG. 10. — Diagram to illustrate a possible mode of convergence of retinal impulses in the human retina.

middle set appears to receive impulses from many rod and cone cells, and one element in the outer set receives impulses from many elements of the middle set. There are, therefore, no indications whatever that every wave length producing the sensation of a distinct color is provided with a private wire for its sole use. On the contrary, the diminution in the number of retinal cells in each layer, and the increasing territory covered by their root-like processes as we pass from the outer surface of the retina inward, indicate very clearly that the so-called ganglionic layers do not serve to still further

complicate the processes going on within the retina, but rather to simplify them, in that they make it possible for the fibrils of the same length in many adjacent rods or cones to deliver their impulses into gradually converging channels.

Many questions arise in this connection that it is as yet hardly profitable to discuss, as, for example: How large an area of rods and cones is tributary to a single optic nerve fibre? Are these areas distinct or do they overlap each other? And, further, to what extent is there a qualitative analysis of impulses previous to convergence; that is, are all the sensations initiated in the long red fibrils of, say, three hundred cones transmitted by a single axis cylinder of the optic nerve, and if something of this kind takes place, is it true only for the red, green, and blue sensations or for ten, or twenty, or more different sensations? But whatever the answer to these questions may be, that there must be, on any theory, some kind of convergence of impulses from the rods and cones towards the optic nerve, is decisively demonstrated by the numerical relations between the rods and cones in the ganglionic cells and the fibres of the optic nerve.

Certain facts appear to indicate that there is a qualitative as well as a quantitative convergence. It is well known, for example, that the stimulation of an area as small as the base of a single cone may produce the sensation of light, but that a considerably larger area must be stimulated before the sensation of any distinct color is produced. This fact is apparently correlated with the distribution of the large ganglion cells of the inner layer, because these cells are more numerous around the fovea than on the periphery of the retina, indicating that there should be less convergence of impulses there than at the outer margin, where one ganglion cell of the inner layer must collect the impulses from a very large number of rods and cones. This appears to be the case, for we can distinguish the colors of small objects better with the centre of the retina than with the periphery; or, rather, small objects which barely produce the sensation of a distinct color when seen with the centre of the retina must be considerably increased in size in order to produce this effect when seen with the periphery.

But what is the disposition of the impulses after leaving the retina? They, of course, follow the optic nerve fibres to the optic ganglion and pass from there to the cerebral hemispheres. But why should we have these two internal centres? The conditions in Acilius furnish a partial answer, I believe, to the question. In the larvæ of this insect there are six pairs of ocelli, and each ocellus happens to have a characteristic size, shape, and arrangement of retinal cells. The nerves to the ocelli unite to form a common nerve, which near the optic ganglion again separates into six nerves, each one ending in a distinct mass of fibrillated substance. These masses of "*Punct-Substanz*" present such a striking resemblance in relative position, size, form, and structural details to the corresponding retinas that there cannot be the slightest doubt as to which ocellus each medullary core belongs. It is not claimed that there is absolute agreement between the retina and its mass of *Punct-Substanz*, but the resemblance goes so far that the singular appendage to retina I, the median furrows in retinas I to V, and the absence of this furrow in the circular retina of ocellus VI, together with the presence of a peculiar patch of inverted cells, are all represented in the corresponding part of the optic ganglion by some change in the number or arrangement of the fibrils. This is a fact of fundamental importance, and while it has been observed only in this instance where the conditions are especially favorable, the principle probably holds good for other animals as well. This similarity between the inner and outer extremities of the visual apparatus indicates that the *Punct-Substanz* of the optic ganglia consists of a series of fibrils which in their numbers and general arrangement agree with the retinidial fibrils to which they are united; and it also indicates that a series of changes initiated by light in the retina are re-presented in the optic ganglion by another sequence of changes having time and spacial relations similar to those in the retina. The whole apparatus is comparable with a telephone, or with a Marconi transmitter and receiver. As the structure of such end organs must be to a certain extent created by the ether waves that rouse them to activity, so the structure and adjustments in the optic ganglion

must be determined in part by the impulses they receive from the retina, just as certain joints, for example, have been produced by repeated stresses and movements of a particular kind. But when such joints are once established, they permit only those kinds of movements that were most instrumental in producing them, whatever may be the nature of the stimulus that initiates these movements. It is, therefore, probable, when certain adjustments have once been established in the optic ganglion through repeated retinal stimulation, that any stimulation of such a collection of fibrils might call forth the particular series of activities necessitated by such an adjustment, whether the initiatory impulse comes from within or from without. In other words, the existence of a second visual centre, or optic ganglion, having a structure similar to that of the retina, may be considered as essential in establishing for past experiences latent records, which can be brought again into activity through other stimuli than those that originally produced them. We are thus provided with a physical basis for the explanation of hallucinations and for certain phenomena of visual memory.

It is clear from known anatomical relations that the visual impulses do not cease at the optic ganglion, but are transmitted to other centres in the cerebral hemispheres, provided such hemispheres are present. While there is no animal in which the optic ganglion is not united with the anterior part of the brain, it is apparently only in the higher arthropods and in the vertebrates that it is united with a definite part of the cerebral lobes. In Limulus and scorpions, where I have made a special study of these conditions, the cerebral visual centres do not resemble in any way the optic ganglia or the retina, but their whole appearance indicates that they consist of masses of cells and fibres that serve to bring the nervous impulses received from the eyes and optic ganglia into relation with various parts of the body.

We are thus led to conclude from a comparison of widely different types of animals that the visual apparatus consists of three principal parts, which phylogenetically are developed in the order named, *viz.:* the *retina*, or receiving centre; the optic ganglion, or recording centre; and the cerebral portion, or the

coördinating and distributing centre. The structural unit of this apparatus appears to be a fibril, many hundreds of which may be present in each rod or ganglion cell. As the retinidial fibrils appear to form loops in the cones by uniting axial and external fibrils, and their central extremities terminate freely, it is possible that the retinal fibrils form elongated ∩-shaped loops, which might be compared to excessively small Hertz's resonators, the spaces between the ends of the fibrils representing the spark gaps. But whatever comparison may be made between these fibrils and any electrical device, it is not to be assumed that they actually vibrate, like tense strings, in harmony with ether waves. But while they presumably act mainly as conductors and resonators, that fact would not exclude their undergoing metabolic changes, resulting in central or peripheral fatigue or temporary exhaustion.

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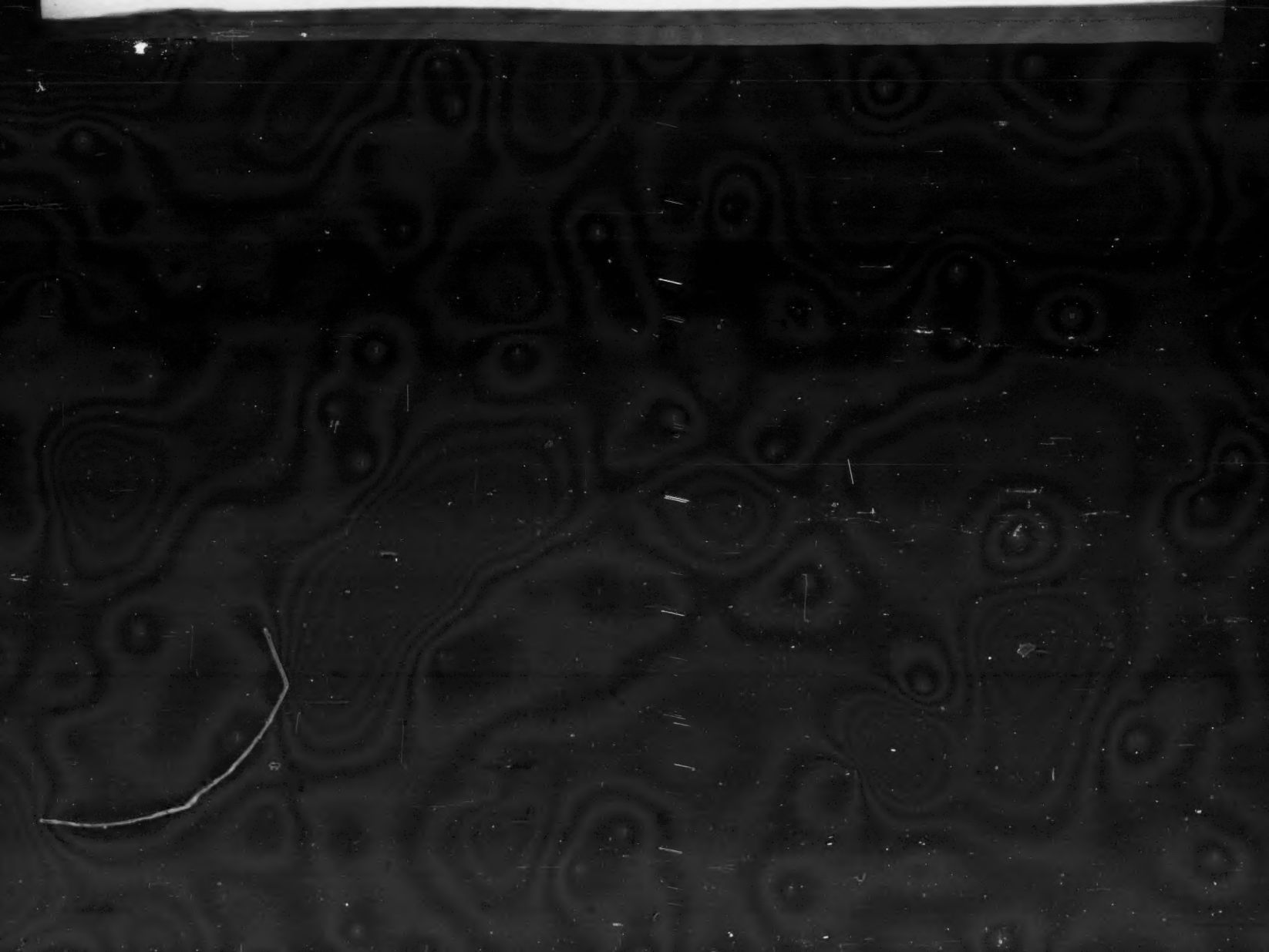


SOME UNIQUE EXAMPLES OF DISPERSION OF SEEDS AND FRUITS.[1]

PROF. W. J. BEAL.

In the driftwood stranded here and there along streams may often be found dry, three-celled fruits of the bladdernut an inch and a half in diameter, brown and light, tough and water-tight. The seeds are very hard and smooth, enabling them, if kept in the water, to remain uninjured for a long time. But the ability to float on the water is not its only means of dispersion. Many of the dry pods hang on until winter, rattling in the wind. On falling, a portion remain near the parent bush and are liable to be carried away the next time the creek overflows its banks; others are moved by the wind, and perhaps again by the water, and still others may be drifted for long distances, even on an up grade, if there chances to be snow on the ground.

Here, among the rubbish in spring, are some shriveled wild grapes, which missed a golden opportunity of being eaten by certain birds which could not digest their bony seeds; but they have in reserve another mode of transportation, not by wing of bird, but by floating on water. Clean grape seeds will sink at once, but when covered by the dry skin and pulp they float. In a similar manner the dry seeds of several dogwoods are often eaten by birds for the pulps, but if not eaten they behave after the manner of grapes with dry, wrinkled skins.

Narrow-leaved dock is a prominent weed, and is especially at home along ditches and river bottoms. On the back of each dry persistent sepal is an ovoid, pithy or spongy tubercle, all of which are not exactly life-preservers, but they are the next thing to it. The naked achene sinks at once when free from everything else, but when encased in its dry calyx it floats on the water.

[1] Read before Section G, American Association for the Advancement of Science, Boston Meeting, August, 1898.

In wet places sedges abound. Those of the genus Carex have each fruit enclosed by a sack (perigynium). In most sedges growing in wet land the sack is considerably larger than the enclosed achene and serves to float the denser portion. Without the perigynium the ripened achene sinks at once.

Some of the lowland sedges, like *Carex stipata* and *C. sterile*, have a perigynium only slightly inflated, but to buoy up the achene well there are small masses of corky substance inside.

Species of Carex which grow on dry land, like *C. pennsylvanica* and the rest of the tribe, have the sack fitting closely instead of inflated, and the whole mass sinks readily in the water.

In the drifted material under consideration are achenes of arrowhead, Sagittaria. They are flattened, and on one edge or both, and at the apex is a spongy ridge that serves the purpose of a raft to float the small seed within, which would sink readily if separated from the light substance that grew on its sides. In this connection may be studied achenes of Alisma, bur reed, cat-tail flag, arrow grass, burgrass, numerous potamogetons, several buttercups, the hop, nettles, false nettle, cinquefoil, avens, and others.

There grows along streams a common grass known as *Elymus virginicus*. A pair of corky, empty glumes adhere to one or more of the mature florets between them and serve as boats to carry the ripened grain to a new spot.

The compressed grain of rice-cut grass (*Homalocenchrus oryzoides*) is enclosed by a pair of glumes, and they float well on the water, but if the glumes are removed the grain drops to the bottom immediately.

Noticeable among seeds in the floodwood are some of the milkweeds, which every one would say at a glance were especially fitted for sailing through the air, aided by numerous long, silky hairs. These hairs are no hindrance to moving by water. The flat seed has a hem-like margin, which must aid the wind in blowing it about, but this margin is thickened somewhat by a spongy material. With the margin attached, it floats; without it, the seed sinks in fresh water.

The bulblets of wild garlic are numerous on the river flats, and they float readily whether dry or growing.

The Kentucky coffee-bean tree is not abundant in southern Michigan, but is oftener found along streams than elsewhere. The large pulpy pods may have induced buffalo, elk, or mastodon or other animals to eat, and thus distribute the very hard seeds, but in these times the pods usually remain on the tree till well dried, even till late in winter. When they dry they will float, carrying the seeds with them, but the seeds by themselves sink at once.

In winter we often see dead tops of lamb's-quarter and the smooth and the prickly pigweeds still standing where they grew in the summer. These are favorite feeding grounds for several kinds of small birds, especially when snow covers the ground, and at such times some of the achenes enclosed in the thin, dry calyx drop to the snow and are scattered by the wind. Birds carry away some of them, the wind blows some over the snow, and still others float on the water, buoyed by the persistent calyx. Without the calyx the achene sinks to the bottom of pond or stream.

The common locust tree blossoms, and large numbers of thin, flat pods are produced; but even when the seeds are ripe, the pods remain of a dull color. The pods of the locust wait and wait, holding fast for a long time, but nothing comes to eat them. They become dry and slowly split apart, each half of the pod usually carrying every alternate seed. Some of the pods with the seeds are torn off by the wind, and fall to the ground sooner or later, depending on the force of the wind. Each half pod as it comes off is slightly bent and twisted, and these are want advertisements given to the wind: "Here I am, thin, dry, light and elastic, twisted and bent already; give me a lift to bear these precious seeds up the hill into the valley or over the plain."

And the wind is sure to come along, a slight breeze to-day tossing the half pod a few feet, leaving it perhaps to be again and again moved further forward. I have seen them transported by this means to the distance of more than sixty yards. But many of the pods stick to the limbs till winter comes. A

breeze tears off a few pods, and they fall on the snow, which has filled up all the crevices in the grass and between the dead leaves and rubbish. Each half pod freighted with seed is admirably constructed, like an ice boat, with sail always to the breeze. In this way there is often nothing to hinder some of the seeds from going a mile or two in a few minutes, now and then striking some object which jars off a seed or two. The seeds are very hard, and no doubt purposely so, that they may be seldom eaten by insects or birds; but once in moist soil, the covering slowly swells and decays, allowing the young plant to escape. Thus the locust seeds are provided with neither legs, wings, fins, nor do they advertise by brilliant hue and sweet pulp, but they travel in a way of their own, and literally on the wings of the wind.

On lowlands, more or less abundant throughout the Northern Temperate Zone, is found the great willow-herb, *Epilobium angustifolium*. When ripe the slender pod slowly recurves from the top into four pieces and exposes the very small seeds, each having at one end a tuft of fine, white, silky hairs nearly half an inch long. Almost every one would think the seeds grew in this manner to be scattered by the wind, and no doubt this is correct. I call your attention to the plant for the purpose of showing that the tips of the hairs stick slightly to grooves inside of the recurved valves, some hairs to one valve, and often others to the adjacent valve, thus spreading them apart with the seed suspended between. Four rows of the seeds are thus held out at one time. Not over half to a tenth part of the seeds are well developed, yet the silky hairs are present and float away in clusters, helping to buoy those that are heavy. This is a capital device, and when dry and unfurled, it silently indicates to the slightest breath of air that the seeds are ready for a flight, and it does not take much to carry them a long distance.

Do you know why so many kinds of plants produce very small and light seeds? Would it not be better if they produced fewer and larger seeds which would be stronger and better able to grow under adverse conditions? But many small seeds cost the plant no more effort than a small number of large ones.

The lighter and smaller the seeds, and the more there are of them, the better their chances for distribution, especially for long distances. The minute size of spores of most of the fungi are given as a reason why so many of them are so widely distributed. Why is a boy or man of light weight secured to ride the horse on the race track? That the animal may have less weight to carry, and thereby use his surplus strength in making better time. The less weight the parachute of the seed of the willow-herb has to carry, the greater the chances for success in making a long journey. Of the willow-herb, it takes one hundred seeds to weigh a milligram, including the hairs attached to them, and it would take thirty thousand to weigh as much as an ordinary white bean.

Ripened pods of *Lilium superbum* usually stand straight up on a stiff elastic stem; beginning at the top, each one slowly splits, and the three parts separate from each other. Why do they not burst open all of a sudden, like pea pods, and shoot the seeds all about, and have the job done with? Or why does not the pod burst open at the lower end first instead of the upper? Observe that the coverings of the cavities are lashed together loosely with a latticework. No slight breeze can dislodge the seeds, but just see how they behave in a gale! The elastic stems are swayed back and forth against each other, and some of the upper seeds are tossed out by the wind which passes through the lattice, and at such times are carried forward. The seeds at the top having escaped, the dry pods split down farther and still farther, and open still wider, till the bottom is reached. Succeeding breezes may come from different directions, and, as the seeds are not all carried away the first, or even the second time, there are some left to be scattered about.

The seeds of the lily are flat and rather light, not to be shot out like bullets, but to be carried a little way by the wind; the pods are erect and open at the top, that they need not escape when there is no wind unless some animal gives the stem a strong shake. I mention this plant on purpose to call your attention to the admirable scheme for economizing the supply of seeds. The latticework was made for a purpose, and the

gradual opening of the pods prevents the supply from all going at one time in one direction or in one day, when a better day may arrive.

We shall find nearly or all flattened seeds or fruits are one-sided, unbalanced, and more or less twisted, so in falling to the ground they whirl about and are thus kept much longer in the air than they would be if shaped more like a winged arrow. Even the wings on the fruit of some of the ashes are twisted, though many of them are flat.

There are a number of rather weedy-looking herbs, common to woods or lowland, known as avens (Geum). They are closely allied to cinquefoil, and all belong to the rose family. The slender styles above the seed-like ovaries of some species of avens are described not as jointed, but straight and feathery, well adapted, as we might suppose, to be scattered by the wind, while others are spoken of as having, when young, styles jointed and bent near the middle. In maturing, the lower part of the style becomes much longer and stouter. When a whole head of pistils has drawn all the nourishment possible, and all that is needed from the mother plant, the upper part of each style drops off, leaving a sharp, stiff hook at the end. At that time each pistil loosens from the head and can be easily removed, especially if some animal touches the hooks. To help in holding fast, there are a number of slender hairs farther down the style which are liable to become more or less entangled in hairs, fur, wool, or feathers. Even in the small number of plants here noticed, we have seen that scarcely any two of them agree in the details of their devices for securing transportation of seeds. I know of nothing like the Geum we are now considering. When young and green, the tip of each hook is securely protected by a knob or bunch with a little arm extending above, which effectually prevents the hook from catching on to anything, but when the fruit is ripe, the projecting knob with its little attachment disappears.

Nycandra physaloides, or Apple of Peru, a coarse annual sometimes cultivated, is spoken of by Gray as bearing dry berries. Each suspended berry is covered by a five-parted inflated calyx. The edges of the sepals come together and

project outward, making a secure covering for the fruit. In time the berry and the papery calyx ripen, and the pedicel becomes stiff and elastic. In five places close up under the calyx the "skin" of the fruit splits open and rolls slowly back, exposing seeds. The dry dehiscent pods of most kinds of plants become wet, close up more or less, and suspend the scattering of seeds in time of a shower. Not so with Nycandra, for each berry is kept dry by an umbrella, cap, or shed, which nature has deftly built. The numerous persistent, inflated calyxes expose much surface to the wind, even after the leaves have left the dry plant. The dead plant is rattled about by every breeze, scattering seeds freely. While these are dropping, the five scrolls on the surface continue to open further and further, permitting more seeds to fall.

Some friends of mine collected a quantity of hazel nuts and placed them near the house, while yet the green husks enclosed the nuts. At once they were discovered by a blue jay, which picked out a nut at a time, flew away, held the nut between its toes, cracked it from the apex, and ate the contents. In this operation a number of nuts slipped away and were lost. Half a dozen or more grew, and to-day a new patch of hazel bushes is growing in the yard.

The unicorn plant (*Martynia proboscidea*) is a coarse diffuse herb found growing from southern Indiana to Iowa and northern Mexico. The ripened fruit is oblong, about three inches long and an inch in diameter, with a beak at the base, and two long, slender, spreading and incurved points at the apex. On the side of the fruit next to the long curved beaks is a crest, consisting of stiff pieces a fourth of an inch long. The whole is tough, hard, and elastic. The three beaks curve toward each other, roughly outlining two-thirds of a circle with a diameter of five inches. It is a queer-looking thing, difficult to describe. A peck of them placed in a basket hold together well, having developed the propensity "to catch on" to a remarkable degree. The three beaks curving toward each other, with the crest inside the ring, adapt it admirably to become attached to the feet of cattle, sheep, horses, and the buffalo, which once roamed over this region in great abundance.

Since reading the above concerning Martynia, J. B. S. Norton, of the Botanical Garden, St. Louis, informed me that he had often seen the points hanging on the feet of cattle or horses on the prairies of Kansas, where the plant in many places has become a bad weed. In some instances several points were seen attached to one foot.

MICHIGAN AGRICULTURAL COLLEGE.

THE ADVANCE OF BIOLOGY IN 1896.

C. B. DAVENPORT.

THE appearance of the second volume of *L'Année Biologique*,[1] with its valuable summaries of progress in general biology, gives the opportunity for a second summary of progress like that published in the *Naturalist* last year.

Cytology. — Five good text-books on this subject appeared during the year by Wilson, by Henneguy, by Fol, by Delage and Hérouard, and by Zimmermann. The idea of a diversity in protoplasmic structure, sometimes fibrillar, sometimes reticulated, sometimes vacuolated, grew, especially among those who at first opposed Bütschli's foam theory of protoplasmic structure. Nadson's discovery of nuclear matter in Cyanophyces was confirmed, with modifications, by Bütschli, who also finds it in bacteria. The chemical constitution of the nucleus received a little attention. Korschelt classified the chromatin as either basichromatin, occurring in one or more large masses, or as oxychromatin, occurring as fine granules. The known distribution of the centrosome was enlarged, its occurrence being recorded for several Protozoa, diatoms, and the ganglionic cells of vertebrates and an invertebrate (Lewis). On the other hand, Strasburger's pupils did not find it in tissue cells of phenogams. The occurrence of a centrosome in ganglionic cells, which are believed not to divide, spoke for its being a permanent cell-organ. The true relation of centrosome to attraction sphere remained to be elucidated.

Cell-division was further analyzed. The universal presence in the spindle of fibres running from one pole to the other became more generally admitted. The discussion over the origin of the spindle continued, great deviations from the type described for the salamander epithelium were made known, and the nuclear origin of the spindle was maintained for both plants and animals. Attention was especially directed, by Erlanger and

[1] *L'Année Biologique.* Edited by Yves Delage. Vol. ii, 1896. Paris, Schleicher Frères, 1898. 8vo., 35 + 808 pp.

Henneguy, towards the accessory cell bodies ("Nebenkerne"), of which several kinds, differing in origin, were distinguished. The idea that amitosis in a cell sounds its death knell was opposed by strong cases.

Experiments to control cell-division were multiplied. The well-known hastening of cell-division by heat was observed again. Induced electric currents provoked direct division in salamander epithelium, and determined that the dividing plane should be transverse to the current (Galeotti). Norman confirmed Loeb's assertion, that in dense solutions cytoplasmic cleavage might be inhibited without interfering with nuclear division. Boveri showed that in a cleavage sphere containing archoplasm, but no chromatin, division of the archoplasm might continue in the absence of chromatin. The independence of nucleus and cytoplasm grew more evident.

The Sexual Products and Fecundation.—Chromatin reduction was observed in Heliozoa (Schaudinn) and Coccidiidæ (Labbé)—thus among the simplest organisms. The history of the origin of the sex-cells and their periods of multiplication and of rest were traced by Eigenmann in a viviparous fish. The question of the locus of the centrosome in the spermatozoon was undergoing debate. As for *fecundation*, the belief that the archoplasm of the female plays no part in egg-cleavage was unanimously confirmed by the several workers upon this subject.

Parthenogenesis. — The observation of last year on the absence of true parthenogenesis in the unfertilized eggs of the higher vertebrates was confirmed. Parthenogenesis in the lower algæ was induced artificially. It was stated (Zur Strassen) that two eggs of Ascaris may fuse, giving rise to a zygote capable of developing into a giant embryo.

Asexual Reproduction. — New cases of reproduction by autotomy were described for a holothurian and a nemertean. Attention was again called (by Seeliger) to the non-parallelism between budding and egg-ontogeny, and Ritter insisted on the origin of buds in Tunicates from embryonic tissue.

Ontogenesis. — The truth that in development preformation and epigenesis are blended, which was dawning in 1895, became still clearer as a result of the work of 1896. Especially was

this due to the results of Crampton, who showed that in the gastropod Ilyanassa, when the mesodermal pole cells are removed, no mesodermal structures are produced in the embryo. Thus there is here, at a certain late cleavage stage, a specialization of cells in the germ. The series of specialization, which finds its lower extreme in the medusa and its higher extreme in the gastropod, is, however, not shown to be one of specialization of nuclear material, but rather of cytoplasmic material only. In so far as the cytoplasm of the germ is specialized, in so far is there preformation in the germ. In so far, on the other hand, as the fate of a portion of the germ is determined by its position in the body, development is epigenetic. The variation in the degree of preformation is due to the fact that the cytoplasm of some eggs exhibits little responsiveness, that of others a great deal. New evidence for the unspecialized character of the nuclei was given by Wilson, who found that potential micromeres of Nereis, forced to become macromeres, had the fate of macromeres. Last year it was shown that one-fiftieth of an echinoid egg might develop; this year Lillie showed that one-twenty-seventh of a Stentor is capable of forming a new individual. Jennings showed that the axis of the spindle in a developing rotifer egg is not always placed in the greatest extent of the cytoplasm (Hertwig's law), but occupies various positions. The spindle is sometimes stimulated by the form of the cell to lie in its long axis, at other times to lie in its short axis, and at still other times to lie obliquely. Among attempts at a mechanical explanation of ontogenesis were those of Roux, who showed that the lines of contact of oil drops resemble those of cleavage spheres. The theory of development as a response to stimuli was enriched by the experiment of Driesch, which showed that the mesenchymatous cells of echinoid gastrulas, disarranged by shaking, return to their respective places. Self-regulation was illustrated by the observations that variations in the embryo are greater than in the adult (whence they must gradually become obliterated during development), that with shortened range of contraction of a muscle its tendinous part is increased at expense of its contractile part, and that a bone called upon to carry an abnormally great weight increases in

diameter. Of these self-regulations Driesch distinguished two categories — primary, involving only normal ontogenetic processes, and secondary, involving ontogenetic processes of a new and special sort.

Teratology. — The most important work of the year in comparative teratology was that of Patten on abnormalities in the development of Limulus. In attempting to produce monstrosities by physical agents, Bataillon made the axis of the embryo frog lie perpendicular to that of the first cleavage plane (hence perpendicular to its normal position) by pressure, Rossi found that electricity has less effect the older the embryo, the fact that the different chemical solutions have specific effects on echinoid ontogeny was determined for echinoids by Herbst and for Amphibia by Gurwitsch, Samassa ascertained that pure oxygen has little effect on the development of the frog, and Féré found that the venom of the viper provokes anomalies in the development of the chick. De Vries showed that a highly nutritive culture-medium tends to accentuate the monstrous characters of individuals of a race of plants which is tending to revert to the normal type. Several unusual and well-worked-out cases of abnormalities in invertebrates were described by morphologists.

Regeneration. — While the multiplication of cases of regeneration continued as in former years, the principal lines of advance in 1896 were first in the clearer recognition of the fact that in regeneration an organ often arises from dissimilar germ-layers and develops in a different manner than it does in egg development ; and, secondly, that regeneration is often accompanied by heteromorphosis. In the first category we have Wolff's case of regeneration of the lens from the mesoderm of the iris of Amphibia, this year abundantly confirmed. According to both Michel and Hepke, the ectoderm of the earthworm gives rise to all the regenerating tissues. In the second category of cases we place the observations that regenerating eyes of shrimps may produce antenniform organs, that the regenerating antennæ of the lobster have a spiral form, that planarians, whose margins have been incised, may form multiple heads, and that the regenerated tails of lizards are of simpler organization

than the normal ones. In the case of Crustacea the normal form of the organ may reappear after several molts (Przibram). A very extended study on regenerations in earthworms was made by Heschler.

Grafting. — This year afforded the marvelously successful results of Joest in grafting earthworms, not only one part of the worm being united to another part, but one individual to another.

Sex and Secondary Sexual Characters. — New experiments on sex control confirmed, on the whole, the idea that femaleness results from rich nutrition. Marchal showed that neuter wasps, when through the death or sterility of the queen there are no young in the nests, feed on the larval food and become fertile females.

Polymorphism, Metamorphosis, and Alternation of Generations. —Some advance was made this year in answering the question, Is polymorphism blastogenic or somatogenic? What rôle do the intrinsic conditions of the individual play, and what environment? No doubt there must be a substratum capable of responding in two or more ways, but which response shall be called into action, and how far it shall go, these are determined by extrinsic factors. The theory that a double habit (*e.g.*, the habit of a gall insect in stinging two kinds of trees) may lead to polymorphism was advanced by Beijerinck.

Correlation. — The most important contribution of the year was that which Pearson made to the mathematical study of the subject. Several authors contributed exact data on correlation in various species. Many special cases of correlation were described.

General Morphology and Physiology. — The discussion over the significance of the cell as a unit in the body was continued in France by Delage and Le Dantec. The idea that metameres are, phylogenetically, secondary divisions of the trunk gained ground.

One of the most important works of the year in general physiology was that of Loew, on the *Energy of Living Protoplasm*, in which the chemical explanation dominated. Progress was made towards a clearer understanding of the way in which sun-

light is transformed into the specific, assimulative energy by chlorophyll. Tschirsch showed that chlorophyll and hæmoglobin probably originate in the same fundamental substance. The question of the process of albumen formation in plants was a burning one. Internal secretions attracted ever-increasing attention. Our knowledge of the rôle and physics of osmosis in organisms and the action on organisms of light, electricity, (Loeb, Verworn), and chemical substances received important additions, as did also phygocytosis and the action of ferments.

Heredity.—The year revealed an increased tendency towards experimentation. Boveri's evidence for a hybrid without maternal characters was almost annulled by the opposing investigations of Seeliger. In the matter of inheritance of acquired characters new experiments by Charrin and Gley indicated the inheritance of immunity. Loeb, testing the hypothesis that the nervous system acts as an intermediary between soma and germ cells, finds that the amphibian larva develops normally even after the axial nervous system has been severed. Very noteworthy is the fact that Ewart repeated Lord Morton's experiment in telegony with somewhat confirmatory results.

Variation.—The quantitative study of this subject has made good progress. Pearson investigated the mathematical laws of regression, heredity, and panmixia. Ludwig, Amann, Warren, and Thompson applied the quantitative methods to the variation of various species. Agassiz and Woodworth found the variations in a medusa — Eucope — only such as are normal in other species. The great variation in embryonic as compared with adult stages was gaining more general recognition.

Origin of Species. — The principal papers of the year were speculative. Weismann added to his system the conception of a struggle in the germ plasm by which those determinants which gain a slight advantage over their fellows soon get the upper hand. The theory of mimicry was strongly attacked (*e.g.*, by Piepers, after many years of observations in the Malays). The struggle around the theories of natural selection and the utility of specific characters continued. Many cases of considerable variations due to environment, forming probable starting points of species, were described.

The Nervous System and Mental Functions. — Great activity was displayed in the study of the structure of the nerve cell, yet the significance of the chromophile substance and the fundamental substance remained in dispute, Ramon y Cajal regarding the former as a nutritive reserve. The variations of the nerve cell in different states of function and health were the subject of much attention. The results of the immense activity in the fields of sensations, instincts, and emotions cannot be summarized.

General Theories. — The most important theoretical work of the year was probably Cope's *Factors of Organic Evolution.* Important also were Weismann's *Ueber Germinal Selection* and Le Dantec's *Théorie nouvelle de la vie.*

Of the subjects considered in *L'Année Biologique* five seem developing with magnificent rapidity — cytology, experimental morphology, general physiology, variation, and the nervous system. Already there are indications of the not far distant blending of the results of the work in all of these lines of investigation.

EDITORIALS.

The New York State College of Forestry. — In April last, the Legislature of New York passed an important Act, authorizing the Trustees of Cornell University "to create and establish a department in said University, to be known as and called the New York State College of Forestry, for the purpose of education and instruction in the principles and practices of scientific forestry." Provision was also made for the establishment of a demonstration forest of not more than 30,000 acres, in the Adirondacks, which is to be known as the "College forest." Since the organization of the several agricultural experiment stations on a national basis of support, no public endowment of applied science has at all approached this of the state of New York in prospective usefulness to the public at large.

From an announcement of the new College of Forestry, recently issued, it appears that the annual consumption of wood materials in the United States is estimated at over 20,000,000,000 cubic feet, valued when shaped for use in the arts at not less than $1,000,000,000. Much of this material is doubtless capable of profitable, even though in the first instance more expensive, replacement by other material; and although many notes of warning have been sounded, and for some years a national forestry association has occupied itself with the formation of public opinion, favorable to a rational administration of our forests, it is probably true to-day that private landowners cannot view investment in forest lands, to be rationally administered, as desirable from a business point of view, partly because of the slowness with which returns are received. But in Europe the necessity of such administration of what is left of the original forests, and of the very large areas that have been planted to take the place of those denuded, has come to be generally understood. Under the management of Professor Fernow, who has been called to its head, the new College of Forestry may be expected to disseminate the best and most practical of information on all matters connected with the subject, and it is probable that long before the expiration of Cornell's thirty years' title to the "College forest," it will have served as the model for many and larger state and national forest reservations, which will be not only safely preserved but administered, for the public benefit.

The Concilium Bibliographicum. — We are glad to receive, unfortunately too late for insertion in the present issue, an account of the work of the Concilium Bibliographicum, from which we learn that this enterprise is now firmly established, the Swiss Confederation, the Canton, and the town of Zurich having voted a permanent subsidy for its support.

The Concilium was founded in 1896, by Dr. Herbert Haviland Field, with the view of furnishing zoologists with a more complete bibliography than had existed heretofore. The plan is to issue a classed card catalogue of current zoological literature, taking into account not only all books and papers issued but also parts of papers when they treat of distinct subjects. This large undertaking has involved an immense amount of work for Dr. Field, as well as a very considerable expense, and he should receive the cordial support of every zoologist.

It is not expected that individuals will care to subscribe for the whole series of cards, and orders will be received for as small a part as any one may want. Every worker in zoology may profit, therefore, by Dr. Field's labor, and at the same time aid him in this most useful and unselfish enterprise.

REVIEWS OF RECENT LITERATURE.

ANTHROPOLOGY.

Prehistoric Burial Places in Maine.[1] — Mr. Willoughby's paper is noteworthy for its exposition of modern methods of archæological research. At every step in the progress of the work of exploration of the three burial places described, sketches, photographs, and measurements were taken with painstaking care so that the author is enabled to present the facts clearly and concisely. His work may well serve as a model for those untrained observers who, sincerely desirous of reading these perishable records of camp site and grave, but too frequently succeed only in destroying them.

The cemeteries explored are shown to be very old; the implements[2] found in them differ somewhat from those used by the Algonquins who inhabited the region at the time of the discovery. We note that the slender spear points of slate resemble those used by the Indians of the Barren Ground of Canada at the present time for killing caribou by thrusts in the back as the animals are swimming across lakes and streams in summer.

In conclusion the author suggests that these cemeteries may have been used by the Beothuks, the last remnant of whom perished in the central part of Newfoundland during the early part of this century. The discovery of a single cemetery of this interesting people would probably solve the problem raised by Mr. Willoughby's investigations, and also determine the relationships of the Beothuks to the tribes around them. A railway has invaded the Red Indian Lake region, and it is now easily accessible; it is to be hoped that a larger series of crania may be discovered, or at least that the few skulls now known may be studied by a trained somatologist.

[1] Willoughby, Charles C. Prehistoric Burial Places in Maine, *Archæological and Ethnological Papers of the Peabody Museum*. Harvard University. Vol. i (1898), No. 6.

[2] In the quotation from Dr. Hough's valuable paper on the Fire-Making Apparatus in the U. S. National Museum the statement is made that pyrites were probably used in kindling fire at Herschel Island (and other points east). This may be regarded as a certainty, as we have collected specimens of Eskimo fire-bags containing pyrites at Herschel Island and know that it is so used.

GENERAL BIOLOGY.

Filose Activity in Metazoan Eggs. — Any new facts that throw light upon the complicated problem of the relations to one another of the cells in an organism are exceedingly welcome. We note with pleasure, therefore, an article[1] by Prof. E. A. Andrews, giving a summary of his researches upon the formation of pseudopodia-like processes in metazoan eggs, to which Mrs. Andrews first clearly called attention in 1897.[2]

The filose processes are described as extremely fine protoplasmic threads arising from the surface of blastomeres in various stages of cleavage. They traverse the blastocœl, and frequently become attached to other blastomeres or to the polar bodies, which also give rise to similar processes. The threads may branch, and the protoplasm flowing along them may collect in nodules, especially at the points of origin of the branches.

These filose phenomena were observed in living eggs of a nudibranch mollusk, *Tergipes despectus* (?); a lamellibranch, *Yoldia limatula;* a nemertean, *Cerebratulus lacteus* Verrill; an annelid, Serpula; and echinoderms.

Among the Chordata, preserved material only was available. In sections of cleavage and larval stages of the salamander *Amblystoma punctatum*, and in certain frog's eggs, undoubted protoplasmic connections between the cells were observed, but their normal filose character was not certain. Eggs of Amphioxus in four, eight, and sixteen-cell stages showed marked intercellular connections. In the illustrations these are seen to be filaments of considerable length, extending across the cleavage cavity. Figures of the filose processes found in living and in preserved echinoderm eggs are introduced for comparison, and support the view that the filaments in the egg of Amphioxus are of the same character.

If the filose phenomena are as widely distributed throughout the animal kingdom as this paper would lead one to suppose, they will become surely an important factor in future theories of ontogeny.

R. P. B.

A Plea for the Theory of Special Creation. — While the methods of evolution still furnish matter for discussion, one might suppose

[1] Andrews, E. A. Filose Activity in Metazoan Eggs, *Zoological Bulletin*, vol. ii (July, 1898), No. 1, pp. 1–13.

[2] *Journ. of Morph.*, vol. xii, No. 2.

that, for scientific people at least, the central fact of organic evolution had been established beyond question. In opposition to this view, we have a book of nearly 400 pages, by Prof. Alfred Fairhurst,[1] who has been "for many years a teacher of various branches of natural science." We doubt, however, whether his arguments will be found convincing by many who have paid very much attention to the biological sciences. The object of the book is "to promote the belief in Theism and in the existence of a spiritual nature in man which Theism alone can explain." Therefore, the author attacks evolution, not because Theism and the doctrine of evolution are necessarily antagonistic, — the author does not think that they are, — but because the belief in Theism in some people has been decreased by the propagation of the theory of evolution.

The difficulties that the author arrays against evolution are the old familiar ones: the origin of living material, the survival of primitive types, divergent evolution, absence of "missing links," the appearance of highly organized forms in early fossiliferous rocks, uselessness of nascent organs, instinct, and the like. He does not attach much weight to the evidence from homologies and vestigeal organs. For example, "they (fins) are said to be homologous to the limbs of higher vertebrates, but I regard the homology as far-fetched." Again, "embryo man with gill arches is still man, and if we can read the lesson within it, we will find that this embryo man points upward to adult man with all of his marvelous powers of mind, and not downward to something infinitely below him."

To properly answer arguments presented from the point of view of this book, one would have to preface his remarks by a treatise on elementary biology, comparative anatomy, and embryology, and introduce a chapter on the natural history of animals and plants, with remarks on fossilization. The limits of a review will hardly permit this.

R. P. B.

Fusion of Pupæ. — In the Woods Holl Lectures for 1896 and 1897,[2] Henry E. Crampton, Jr., gives an interesting account of his experiments upon the pupæ of Lepidoptera. By cutting away portions of two pupæ, and joining the cut surfaces, he was able in many

[1] Fairhurst, Alfred. *Organic Evolution Considered.* St. Louis, Christian Pub. Co., 1897. 8vo., 386 pp.

[2] Crampton, Henry E., Jr. Coalescence Experiments upon the Lepidoptera, *Biological Lectures delivered at the Marine Biological Laboratory of Woods Holl.* Boston, Ginn & Company, 1898. pp. 219–228.

cases to obtain a firm union, and in due time a compound imago would emerge, generally with the help of the operator, however.

All attempts to join lateral halves of two different pupæ were unsuccessful, and the proportion of failures was large in all the series, but there were enough successful cases to give some interesting results.

It was found to be a little more difficult to unite pupæ belonging to different species or genera, than where the two components belong to the same species. Thus, of the former category only 7 cases out of 62 resulted favorably, while 14 out of 95 were successful of the latter. In regard to the way in which the parts were united, — in cases of union in normal proportion the successes were 4 out of 61, in "tandems" they were 3 out of 27, and in twins, *i.e.*, union of homologous parts, back to back, etc., they were 14 out of 69, over 20 per cent.

The results in regard to reciprocal color effects were inconclusive, and we still await the histological details. R. P. B.

ZOOLOGY.

The Fresh-Water Fauna of Ceylon.[1] — Seven collections in five localities in the swamps and lakes of Ceylon have afforded Dr. E. von Daday the opportunity of increasing the list of the known micro-fauna of this island from 42 to 170 species, 39 of which he describes as new. The 31 Protozoa observed in the collections or raised from dried moss are mainly cosmopolites, as are also the 42 species of Rotifera. Among the Entomostraca the Cyclopidæ alone are represented by cosmopolitan species, while the Cladocera have a smaller ratio of such forms mingled with others having an Oriental, Ethiopian, or Australian distribution. The Centropagidæ and Ostracoda are represented exclusively by species confined to the three regions named. This examination of the micro-fauna indicates that Ceylon is a meeting ground for the Palæarctic, Oriental, Ethiopian, and Australian types of minute life. C. A. K.

Butler's Birds of Indiana. — For a number of years Mr. Amos W. Butler has been a diligent and intelligent student of the higher verte-

[1] Daday, E. Von. Mikroskopische Süsswasserthiere aus Ceylon, *Termes. Füzetek*, Bd. xxi, Anhangsheft. Budapest, 1898. 123 pp., 85 illustrations.

brates of Indiana, his first paper upon the birds dating from 1882. In 1890 he published an annotated catalogue (135 pages) of the birds of the state, and now we have a more pretentious paper from him,[1] enumerating 321 species actually known from the state, and in a supplementary list 81 additional species, which, while occurring in adjacent states, have never been reported from Indiana. The present volume is more than a catalogue; it is a manual of the ornithology of the state, with analytical keys, descriptions of the species, and bits of bird biography, some copied, but many original and showing a familiarity with the birds in the field. A greater value to the agriculturist is found in the accounts of the economic importance of many species, especial stress being laid upon the food and upon the agency which many birds perform in the distribution of the seeds of useless and noxious plants. The *American Naturalist* has often had occasion to speak in high terms of the zoological work done in Indiana, and this work by Mr. Butler is but another instance in the same line.

Fishes of the Canary Islands. — In the *Proceedings of the Academy of Natural Sciences of Philadelphia* is a list of fishes collected by O. F. Cook, at the Canary Islands. Fifty-four species are enumerated, four of them new. The fauna of these islands is essentially that of the Mediterranean, showing little in common with the West Indies. There are, however, some differences from the Mediterranean fauna, appearing in the fact that some of the common types of the latter are replaced by closely allied but distinct species. There is no evidence of difference between the Canary fish fauna and that of the Madeiras.

Development of Chilopods. — All facts concerning the development of the Chilopoda are of interest, and this short paper by Dr. Heymons[2] contains much of importance. A complete paper is promised later. The egg contains a central unsegmented yolk with segmentation nuclei. Some of the segmentation cells migrate to the surface and from the blastoderm. The yolk-cells arise in part from the nuclei which remain in the yolk, in part from elements which arise from the blastoderm. These immigrant yolk-cells cannot be distinguished from the entoderm cells, which arise in the same manner from all parts of the ectoderm. A gastrular groove does not exist.

[1] The Birds of Indiana. Ext. *22d Report of the Department of Geology and Natural Resources of Indiana*, 1897. pp. 515–1187. (Published 1898.)

[2] *Sitzungsber. k. preuss. Akad. Wissensch.*, Bd. xviii (1898).

The entoderm cells arrange themselves as a one-layered epithelium. The body consists of a primary cephalic plate, a primary anal piece (telson), and the metameres between these, as follows: (1) an antennular segment; (2) antennal segment; (3) intercalary segment; (4) mandibular segment; (5 and 6) two maxillary segments; (7) segment of the maxilliped; (8–28) body segments; (29 and 30) genital segments. These are shown not only by the external appearances but by the ganglia as well. The protocerebrum consists of (1) the archicerebrum arising in the clypeus; (2) two pairs of ganglia in the primary head plate; (3) the optic ganglia (which arise by delamination); (4) a pair of ganglia in the antennular segment. The antennal[1] segment gives rise to the deutocerebrum, while the intercalated segment gives rise to the tritocerebrum. There is no ganglion in the telson. The sympathetic system arises from the fore-gut; the dorsal cardial nerve from the mid-dorsal ectoderm. The head or salivary glands are purely ectodermal and cannot be compared to nephridia. Cœlomic cavities occur in each segment (thirty pairs), the cephalic plate and telson excepted. The unpaired gonad and its duct are paired in origin, and their cavities arise from the cœlom, and in the adult traces of the left of the two primary ducts can be found. The genital ducts have, as in Hexapods, an ectodermal termination, from which arise the two paired accessory glands.

These facts go to show a close relationship to the Hexapods, and to support the view that chilopods and diplopods are, at least, very remote from each other; in other words, that a natural group of myriapods does not exist.

J. S. K.

The Aarbog, of the Bergen (Norway) Museum for 1897 maintains the high standard of this publication in the past. Among the papers which it contains are the following: R. Collett, an account of the beavers in Norway, illustrated by a dozen half-tone plates from photographs. The number of beavers now existing in Norway is estimated at about 100. Collett found no parasites on any of the specimens which he examined. K. F. Koldrup reviews the rocks of the Ekersund-Soggendal region. James A. Grieg describes a specimen of the cetacean *Mesoplodon bidens*, stranded on the Norwegian coast in 1895, with notes on other Scandinavian specimens. He contributes in a second paper notes on other cetaceans. R. Collett describes and figures a hybrid between *Lagopus mutus* and *Tetrao tetrix*. K. E. Schreiner describes the eyes of several free-living chætopods.

[1] Heymons says antennular segment, evidently a slip of the pen.

The sixty-fourth volume of the *Zeitschrift für wissenschaftliche Zoologie* begins with a monograph (384 pages) of the serpents belonging to the family Boidæ, by J. Zenneck, of Strassburg. He enumerates 69 species, and had as material for his studies over 560 specimens. The article is illustrated by eight plates of details, color patterns, etc.

Under the title "The Karkinokosm, or World of Crustacea," the Rev. Thomas R. B. Stebbing is publishing in *Knowledge* a series of interesting popular articles on Crustacea. The illustrations, selected from various sources, are well reproduced.

BOTANY.

Frank's Agricultural Botany. — Nearly every art and profession gradually gathers to itself a special series of text-books in allied sciences. To those expounding that part of botany most useful to the student of agriculture is now added an English translation of the little manual of Professor Frank of Berlin.[1] While the occasion for such a book may not be obvious at a first glance, its author enjoys a reputation in the field chosen which entitles his work to a place wherever scientific agriculture is taught.

T.

The Wisconsin Survey. — In common with most of the richer states, Wisconsin has at various times provided for the exploration of its natural resources, but for some years no appropriations had been made for the continuation of this important work until about two years ago, when, the matter having been taken in hand by the State Academy of Sciences, Arts, and Letters,[2] a legislative appropriation was obtained for the prosecution of a new geological and natural history survey of the state. When it was learned that Professor Birge had been made director, it became evident that the work would be conscientiously and efficiently carried on in such a manner as to supply both scientific and economic results. The recent publication of the first two bulletins of the Survey[3] justifies

[1] *A Manual of Agricultural Botany.* From the German of Dr. A. B. Frank. Translated by John W. Patterson. Edinburgh and London, William Blackwood & Sons, 1898. x + 199 pp., 133 illustrations.

[2] *Trans. Wis. Acad.*, vol. x, p. 595. 1 map.

[3] *Wis. Geol. and Nat. Hist. Survey.* Bulletin No. 1 (Economic Series, No. 1). On the Forestry Conditions of Northern Wisconsin. By Filibert Roth. vi +

the hopes entertained, and there is every reason to expect that other bulletins now in hand will be equally useful. T.

Life Zones and Crop Zones. — Under this title Dr. C. Hart Merriam has recently published an important bulletin from the division of biological survey of the United States Department of Agriculture. The paper is accompanied by a map, in color, which shows at once the distribution of what are called the boreal, transition, upper austral, lower austral, Gulf strip of lower austral, and tropical zones, and the humid divisions of the austral zones east of the great plains. If, as the author hopes, this and similar reports tend to guide experimental agriculture into rational lines, it will be paid for in saving to the country many times over in a single year. T.

Bray's Lower Sonoran Flora. — In the *Botanical Gazette* for August, Prof. W. L. Bray publishes an important paper "on the relation of the flora of the lower Sonoran zone in North America to the flora of the arid zones of Chili and Argentine," in which are embodied the results of studies carried out at the suggestion of Professor Engler of Berlin. The general conclusion is reached that for most species the distribution and relationships in the two zones are such as can be accounted for from data that are reasonably well established, while the element which remains rests upon very much the same basis of speculation as the relation of all of the great salt desert regions of the world to each other.

East Indian Iron Woods. — *Bulletin No. 19* of the Koloniaal Museum of Haarlem, issued in July, is devoted to a consideration of the anatomical structure of the iron woods of the Indies, to which is added a list of plants from other parts of the world to which this name is applied. A set of very good cross-section plates adds to the usefulness of the article.

Botanical Notes. — The September number of the *Bulletin of the Torrey Botanical Club* contains No. 16 of Dr. Small's studies in the botany of the southeastern United States, chiefly occupied with descriptions of new species peculiar to that region; a paper by Professor Porter on the flora of the lower Susquehanna; No. 24 of the

78 pp., with 1 map. — Bulletin No. 2 (Scientific Series, No. 1). On the Instincts and Habits of the Solitary Wasps. By George W. Peckham and Elizabeth G. Peckham. iv + 245 pp., 14 pls. Madison, 1878.

enumeration of Dr. Rusby's plants collected in South America in 1885–1886; the description of a new Floridan Utricularia, by J. H. Barnhart; and a paper by Ellis and Everhart, descriptive of new species of fungi from various localities.

H. B. Small, in *The Ottawa Naturalist*, is publishing a series of popular articles on vegetation in the Bermudas.

The genus *Arenaria* is revised in a descriptive monograph in Nos. 232, 233 of the *Journal of the Linnean Society*, dated July 1, 1898, by F. N. Williams, whose critical notes on *Cerastium* are running through the current numbers of the *Journal of Botany*.

Ledum glandulosum, of the northwest coast region, is well figured in No. 1338 of the *Botanical Magazine*.

Viburnum tomentosum and its variety *plicatum* form the subject of an interesting illustrated article by A. Rehder in Möller's *Deutsche Gärtner-Zeitung* for August.

Aristolochia sipho, as grown in the botanical garden at Jena, is figured in Möller's *Deutsche Gärtner-Zeitung* of August 13.

The *Liliaceae* of the French Congo are brought together in a revision by Hua in the *Bulletin of the Société d'Histoire Naturelle d'Autun* for 1897. As might have been expected, a large part of the species are described as new.

Under the title *Studies on American Grasses*, the United States Department of Agriculture issues as *Bulletin No. 11* of its Division of Agrostology a revision of the North American species of Calamagrostis, by T. H. Kearney, and descriptions of a number of new or little-known grasses, by F. Lamson-Scribner. Seventeen plates and twelve figures in the text illustrate the papers.

The *Bulletin* of the Natural History Society of New Brunswick, No. 16, recently issued, contains a list of 245 mosses occurring in the Province.

In the July number of *Hedwigia*, Rehm publishes a fourth part of his notes on the fungi collected in Brazil by Ule, and Dietel publishes some observations on the Uredineae of Mexico.

SCIENTIFIC NEWS.

For many years Canon A. M. Norman has been a diligent student of the marine invertebrates of northern seas, and as a result has accumulated collections rich in types of his own and his collaborator's new species. These have now been purchased by the British Museum.

Prof. Michael Foster will be president of the British Association at the meeting at Dover in 1899.

Dr. W. McM. Woodworth has gone to the Samoan Islands in the interest of the Museum of Comparative Zoology.

The anthropological expedition, under charge of Prof. Alfred C. Haddon, has reached Murray Island, where a laboratory has been established in the same building which Dr. Haddon occupied during his previous visit to the island.

The United States Fish Commission has rediscovered a school of the valuable and interesting tile fish about seventy miles south of Martha's Vineyard.

Sir William Flower has resigned the directorship of the British Museum (Natural History) on the grounds of ill-health.

The British government is establishing a botanic garden and experiment station in Uganda under the direction of Mr. Alexander Whyte.

A striking commentary upon the demand for agricultural education is furnished by the enrollment last year in the State University of the agricultural state of Nebraska. Out of a total enrollment of 1915 there were 36 in the agricultural and mechanical school.

Dr. A. Möller, of Eberswald, Prussia, is engaged on a life of Fritz Müller, and desires letters, etc., which will aid in the preparation of his memoir.

John P. Marshall, professor of geology in Tufts College since its foundation (1855), has been made professor emeritus.

Mr. R. D. Lacoe, of Pittston, Pa., has added to his gifts to the National Museum the fossil insects in his collection, amounting to many thousand specimens.

At the annual meeting of the Marine Biological Laboratory at Woods Holl, August 9, the following trustees were elected to serve for four years: E. G. Conklin, Camillus G. Kidder, Maynard M. Metcalf, William Patten, D. P. Penhallow, and W. B. Scott. The other trustees hold over. The officers elected were: Henry F. Osborn, president; Charles O. Whitman, director; James I. Peck, assistant director; Hermon C. Bumpus, secretary; and D. Blakely Hoar, treasurer. It is hoped that when the books for the year are closed there will be no deficit.

Mrs. Emmons Blaine has given $250,000 to Chicago University for the establishment of a College for Teachers.

The Hayden geological medal of the Academy of Natural Sciences of Philadelphia was awarded for the year 1898 to Dr. Otto Martin Thorell, director of the Geological Survey of Sweden.

About 200 attended the International Mining Congress at Salt Lake City last July. The meeting was scarcely international except in name. The next congress will be held in Milwaukee in 1899.

Dr. O. Seydel, lecturer on osteology in the University of Amsterdam, well known for his researches on the Organ of Jacobson, has resigned and returned to Germany.

Lionel S. Wiglesworth, having completed his work on the birds of Celebes, has resigned his position as assistant in the zoological museum at Dresden.

Those familiar with the Academy of Natural Sciences of Philadelphia know how deeply it is indebted to the late Joseph Jeanes and his brother. His sister, Miss Anna T. Jeanes, has recently given the academy $20,000, the income to be used for museum purposes.

The following appointments have been announced: Dr. Cleveland Abbe, Jr., professor of geology in Western Maryland College. — N. Andrussow, professor extraordinarius of geology and paleontology in the University of Dorpat. — Dr. F. J. Becker, of Prag, professor of mineralogy in the University of Vienna. — Dr. Johannes Behrens, extraordinary professor of botany in the technical school at Karlsruhe. — Dr. Max Blanckenhorn, of Erlangen, assistant on the Geological Survey of Egypt. — Dr. Böhmig, professor extraordinarius of zoology in the University of Gratz. — Herbert Bolton, of Manchester, curator of the museum at Bristol, England. — Dr. A. Bühler, privat-docent for anatomy in the University of Würzburg. — Prof. Ladislaus

Celakowsky, director of the newly established botanical gardens of the Bohemian University of Prag. — H. C. Chadwick, curator of the biological station at Port Erin, Isle of Man. — Miss Agnes M. Claypole, assistant in histology and comparative anatomy in Cornell University. — E. G. Coghill, assistant in biology in the University of New Mexico. — Dr. Carl Isidon Cori, professor extraordinary of zoology in the German University of Prag, and director of the zoological station at Trieste. — Dr. Friedrich Dahl, assistant in the zoological museum in Berlin. — R. A. Daly, instructor in physiography in Harvard University. — M. Demoussy, assistant in vegetable physiology in the museum of natural history of Paris. — Paul A. Genty, director of the botanical gardens of Dijon, France. — Miss Gertrude Halley, demonstrator of anatomy in the University of Melbourne. — Dr. R. A. Harper, professor of botany in the University of Wisconsin. — Mr. J. H. Holland, curator of the botanic gardens at Old Calabar. — Dr. Z. Kamerling, assistant in botany in Munich. — Dr. Georg Karsten, professor extraordinarius of botany in the University of Kiel. — Dr. Georg Klebs, of Basel, professor of botany in the University of Halle. — Gregorius A. Kogevnikoff, privat-docent for zoology in the University of Moscow. — Dr. Fr. Kopsch, privat-docent for anatomy in the University of Berlin. — Dr. Kriechbaumer, curator of the zoological collections at Munich. — Dr. P. Kuckuck, custodian of the botanical collections of the Biological Institute of Heligoland. — Dr. Willy Kückenthal, of Jena, professor of zoology in the University of Breslau as successor to Carl Chun. — Dr. W. Kulczycki, privat-docent for zoology in the University of Lemburg. — Prof. E. Ray Lankester, of Oxford, director of the British Museum (Natural History), South Kensington. — A. Lawrski, privat-docent in mineralogy in the University of Kazan. — F. S. Maltby, assistant in bacteriology in the University of New Mexico. — Dr. Heinrich Monke, of Breslau, collaborator in the geological office in Berlin. — Dr. C. C. O'Harra, professor of geology and mineralogy in the South Dakota School of Mines. — N. Th. Pogrebow, secretary and librarian of the geological committee of St. Petersburg. — Georges Pruvot, of Grenoble, chief of the department of practical and applied zoology in the University of Paris. — Prof. Alfred Elias Törnebohm, director of the Swedish Geological Survey. — Dr. Ernst Vanhöffen, assistant in the zoological institute at Kiel. — A. Vayssiere, professor of agricultural zoology in the faculty of sciences at Marseilles, France. — John Vinezielt, assistant professor of biology and director of the bacteriological laboratory in the University of New Mexico. — Dr.

Benno Wandolleck, assistant in the zoological museum in Dresden. — Dr. A. Zalewski, privat-docent for botany in the University of Lemburg.

We regret to announce the following deaths: August Assmann, student of Lepidoptera, at Breslau. — E. B. Aveling, assistant in physiology in the University of Cambridge, aged 47. — Dr. Victor Becker, anthropologist, at Oudenbosch, Holland, February 10. — Dr. Eduard Albert Bielz, in Hermanstadt, Germany, May 26, aged 72 years. — Dr. Paul Brocchi, zoologist, at Paris. — Dr. Ernest Candèze, student of the Coleoptera, in Glain, Belgium, June 30. — Ferdinand Julius Cohn, professor of botany in the University of Breslau since 1859, June 25, aged 70 years. — J. Gallois, entomologist, at Déville les Rouen, France. — Dr. Carlo Giacomini, professor of anatomy in the University of Turin, July 5. — Samuel Gordon, zoologist at Dublin, April 29, aged 82. — Mariano de la Paz Graells, entomologist and professor of comparative anatomy in the University of Madrid, February 13, aged 80. — Rev. Walter Gregor, zoologist, near Aberdeen, Scotland. — Dr. Gümbel, geologist, at Munich, June 18, aged 75. — James I'Anson, mineralogist, at Darlington, England, March 30, aged 53. — Joseph Jemiller, student of Hymenoptera, in Munich. — Anton Kerner, professor of botany in the University of Vienna. — Prof. Leopold Krug, botanist, near Berlin, April 5, aged 63. — Dr. Johan Lange, botanist, and formerly director of the botanical gardens at Copenhagen, April 3, aged 80.

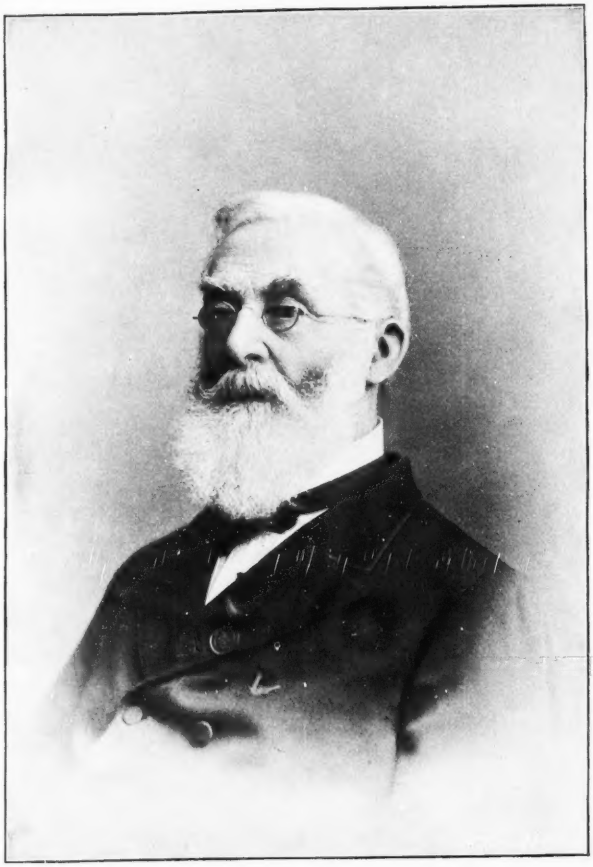
Doubtless some of our readers will be interested to learn from our advertising pages that extras of many of the papers of the late Professor Cope have been placed on sale. No one has done so much work and such good work upon the American vertebrates, living and fossil, as he; and his papers are absolutely necessary for the student of these forms.

PUBLICATIONS RECEIVED.

ACLOQUE, A. Faune de France. Thysanoures, Myriapodes, Arachnides, Crustacés, Nemathelminthes, Lophostomes, Vers, Mollusques, Polypes, Spongiaires, Protozraires. Paris, J. B. Baillière et Fils, 1898. 300 pp., 1664 figs., 12 mo. — BUTLER, A. W. The Birds of Indiana. From *Twenty-second Report of the Department of Geology and Natural Resources of Indiana.* 1187 pp., 8vo. — FAIRHURST, ALFRED. Organic Evolution Considered. St. Louis, Christian Pub. Co., 1898. 386 pp., 12mo, $1.50. — FISH, PIERRE A. Practical Exercises in Comparative Physiology and Urine Analysis. Ithaca. Published by the author, 1898. 71 pp., 75 cts. — GEGENBAUR, CARL. Vergleichende Anatomie der Wirbelthiere mit Berücksichtigung der Wirbellosen. Erster Band. Einleitung, Integument, Skeletsystem, Muskelsystem, Nervensystem und Sinnesorgane. Leipzig, Wilhelm Engelmann, 1898. xiv + 978 pp., 8vo, 619 ills., Marks 27. — MILLS, WESLEY. The Nature and Development of Animal Intelligence. New York, Macmillan Co., 1898. xii + 307 pp., 8vo, $2.00. — ROWLEY, JOHN. The Art of Taxidermy. New York, Appleton, 1898. xi + 244 pp., 8vo, 29 plates and 59 text-drawings.

Boletin del Instituto Geologico de México. No. 10. Bibliographia geologica y minera de la Republica Mexicana, 1898. — *Bulletin of the Geological Institution of the University of Upsala.* Vol. iii, Pt. 2, No. 6, 1897. Upsala, 1898. — *Bulletino del Laboratorio ed orto Botanico R. Universita degli Studi di Siena.* Ann. I. Fasc. 2–3, June, 1898. — *Geographical Magazine.* Vol. xii, Nos. 2, 3, August and September. — *Journal of the College of Science, Imperial University of Tokyo, Japan.* Vol. x, Pt. 3. GOTO, S. The Metamorphosis of Asterias pallida, with Special Reference to the Fate of the Body-Cavities. Vol. xii, Pt. 1. JACOBI, A., Japanische geschälte Pulmmaten. May, 1898. — *La Nuova Notarizia.* Serie ix. September, 1898. — *Memorias y Revista de la Sociedad Cientifica "Antonio Alzate."* Tome xi, Nos. 5–8. Mexico, 1898. — *Proceedings Biological Society of Washington.* Vol. xii, pp. 157–170, August 10. BANGS, O. On Some Birds from Pueblo Viejo, Columbia; Descriptions of Some New Mammals from the Sierra Nevada de Santa Marta, Columbia; a New Race of the Little Harvest Mouse from West Virginia. PREBLE, E. A. Description of a New Weasel from the Queen Charlotte Islands, B. C. — *The Insect World.* Vol. ii, No. 6, June, 1898. Zifu, Japan. — *University of Kansas, Experiment Station, Sixth Annual Report of the Director.* Contagious Diseases of the Chinch Bug. Lawrence, May, 1898. *Zoologist.* Nos. 685, 686, July, August.

(Number 382 was mailed October 26.)



JAMES HALL.

From the "Scientific American."

ERRATUM.

Through an oversight for which the author was not responsible, the cuts for Figs. 5 and 6 of Dr. Eastman's article on p. 766 of the October number were interchanged. The lowermost figure is the dorso-median plate of *Titanichthys clarkii* Newb., lacking the *carinal* instead of "cranial" process, and is reduced $\frac{1}{16}$ instead of $\frac{1}{21}$ natural size.